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Vol. 24 AUGUST, 1932 No. 8

SOME QUANTITATIVE ODOR DETERMINATIONS[1]

By Charles H. Spaulding[2]

It used to be said of the packing industry that everything in the pig was being saved and used except the squeal. Similarly it might have been said of water purification a few years ago that everything could be handled except the smell. However, water purification has been driven by public demand to find cures for odors and tastes as well as for the more familiar chemical and bacterial problems.

Perhaps it would be well to point out that the importance of tastes and odors is not solely in the mind of the public. The average man cannot carry a laboratory with him and must rely on appearance, odor and taste for final advice as to whether his food and drink are fit for consumption. His reflexes having been trained from birth, he cannot avoid a feeling of uneasiness if there is a deviation from normal. This is his protection. Not long ago a druggist reported that his customers frequently complained of the taste of soft drinks from his fountain. He wondered if our treatment was at fault. It was not; but his carbonated fountain water was found to contain a large amount of lead which had been dissolved from some part of his fountain equipment by the water after it had been heavily charged with carbon dioxide. Obviously, the taste of the water was the only

[1] Presented before the Illinois Section meeting, April 12, 1932.

[2] Superintendent of Water Purification, Department of Water, Light and Power, Springfield, Ill.

warning which the customers or proprietor had. More recently, a complaint of the taste of drinking water in an office building led to the discovery that the refrigeration coils on the drinking water system were leaking carbon dioxide into the water. This made the water sufficiently corrosive to dissolve the zinc from galvanized pipe. The water had a metallic after-taste and a sample analyzed contained 20 p.p.m. zinc. Again, taste observers working with concentrates obtained by distilling off the odor and taste compounds by a method used by Trowbridge are sometimes made sick. If the unconcentrated odors and tastes act somewhat in proportion, then the total effect on a large community may be a very large item. A loss of only 1 percent in the happiness, efficiency or man power applied to a city of 100,000 population becomes equal to a total loss of 1000 souls. Such figures are merely speculative, of course, but they should be impressive enough to show that we are not dealing merely with silly whims.

In spite of the fact that a lot of methods are being used with considerable success in combating tastes and odors, we really know little of the proper fields and limitations of various kinds of treatment. This is partly because we have not identified the particular chemical compounds, with a few exceptions, and partly because we have never measured the tastes and odors quantitatively either before or after treatment.

Some of our reports of taste and odor elimination are reminiscent of patent medicine testimonials. They might be paraphrased somewhat as follows: "I was suffering from acute attacks of odor and taste so terrible that the public complained incessantly and life was not worth living. One day a friend advised me to try so and so's carbon (chloramine, aerator or some other cure). I bought one sack and got instant relief. Since then I have never been without this life-saver and use it daily as a prophylactic, regardless of whether I need it or not."

A quotation from Lord Kelvin fits this case admirably: "If you can measure that of which you speak, and can express it by a number, you know something of your subject; but if you cannot measure it, your knowledge is meagre and unsatisfactory."

We may as well admit that no method of measuring odors has been in general use. The determination according to "Standard Methods" is not a measure at all, but merely an expression of opinion as to how well the public will like the water. The same system applied to hard-

ness and turbidity would be considered ridiculous. We cannot as yet determine quantitatively many of the actual compounds causing odor, but we can measure their effects on the sense of smell just as we measure turbidity by sight.

THE DILUTION METHOD OF MEASUREMENT

The writer claims very little originality in applying the dilution method to water. The principle is not new and the procedure can probably be improved. After adopting the idea, I found it was well recognized in chemistry and that the International Critical Tables contain lists of odor values assigned to various chemical compounds based on the threshold value, that is, the highest dilution at which the odor can still be detected. The unit of this system is the "olfacty."

The method we use has already been described and will be only briefly indicated here.[3] It consists of finding the highest dilution of the unknown which can be differentiated from odor free water. If this dilution is 1 to 25, then the odor is 25. If it is 1 to 100, the odor is 100; and so on. There is a curious sort of embarrassment and skepticism which usually afflict the beginner in this operation, due no doubt to the fact that he has never used his nose for a yardstick. It usually takes several days to get a nose broken-in, figuratively speaking, but after that there seems to be no wide divergence in results by different observers. We expect agreements within about 20 percent in the range of 0 to 1000 which covers our experience.

Having found this new tool, we were anxious to try it, like a boy with a new knife; so, in driving about here and there, we took some samples of which a few will be mentioned. First, there were samples from a plant where water was being aerated by diffusion, coagulated, treated with powdered, activated carbon filtered and chlorinated. These showed values of 25 on the raw water, 15 on the aerated, and 15 on the filtered and chlorinated water. The filtered and chlorinated sample had just as much odor as the aerated, in spite of the carbon and purification process. The final odor was distinctly chlorinous, but the results seemed satisfactory to the operator at least.

Next, a sample of filtered and chlorinated water from a softening plant employing no odor removal process was found to have an odor

[3] Charles H. Spaulding, American Journal of Public Health, 21: 9, September, 1931.

of 9, described as chlorinous. It may be noted at this point that odors of more than 5 can usually be detected by ordinary, close observation.

Another sample from a reservoir supply having no purification plant had an odor of 20, grassy. This was taken during the middle of November, when odor problems have usually subsided.

Another plant having a very turbid supply which was coagulated, treated with powdered carbon, chlorinated, settled and filtered, had an odor of 20 on the raw water and 1 on the filtered. The odor of the raw water was distinctly earthy and probably closely associated with the high turbidity. It would have been interesting to know what reduction would have been obtained without the carbon.

On several occasions the effluent of a carbon filter at a bottling works was tested. The city water flowing to the filter had an odor of 4 or 5; while the effluent of the filter had an odor of 8. These results are not cited to discredit recognized methods of odor removal, but to show the advisability of having a measure by which to control the processes.

The effect of various steps of purification on the odor of the water as it passes through a softening plant can be clearly seen by reference to figure 1. In this plant the water is aerated through nozzles, treated with lime, ammonia and chlorine, settled in a clarifier, recarbonated with carbon dioxide gas, mixed with sludge from a second settling tank (clarifier) and with activated carbon when desirable, settled in the second clarifier, and filtered. The ammonia is used to prevent chlorinous odors and to hold the residual chlorine. It has no effect on the natural odor of the water so far as we have been able to detect. Figure 1 shows that at times the aerator assists in odor removal; while at other times it is of no apparent help. The greatest reduction occurs in the first clarifier, following the application of lime and settling. The small amount of aeration incidental to recarbonating has no further effect. In fact, no more reduction occurs unless activated carbon is used, in which case there is another improvement noted as the water enters the filters.

We should not attempt to generalize from a few individual tests such as these, but it may be useful to look for explanations of the results at different stages. The raw water comes from a relatively shallow reservoir which is often agitated by strong breezes. The more volatile odor compounds, therefore, have an ample opportunity to escape before the water enters the plant at such times.

The aerator is not one that breaks the water into fine drops, and its work is already done when the water reaches it, at least part of the time.

The action of the lime precipitate in removing odor is probably twofold. The larger part of the benefit is doubtless due to the sweeping out of algae and suspended matter by the heavy precipitate. The fresh sludge at such times may be very offensive in odor and green in color. Part of the benefit, however, is probably due to absorption of the odor compound by the finely divided calcium carbonate and magnesium hydroxide precipitate.

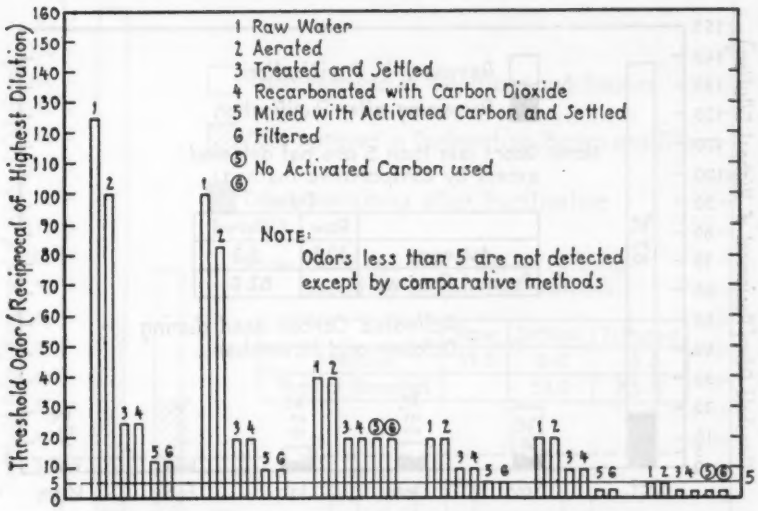

FIG. 1. ODOR REMOVAL AT A WATER SOFTENING PLANT. BLOOMINGTON, ILLINOIS

The effect of the activated carbon is usually evident, but not as marked as might be hoped. For complete removal of odor, we have found at times that 600 pounds per million gallons of powdered carbon would be required, and this amount would not only be expensive, but impossible to remove on the filters. The improvement obtained, however, is considered too valuable to omit whenever the filtered water effluent reaches an odor much above 5.

The monthly averages of odor determinations at the same plant are shown in figure 2 beginning with October, 1931, after which date daily tests were made regularly. Except for a brief period in April, no serious odor problems had appeared at this plant until the latter

part of September. Then a sudden growth of clathrocystis changed the water to green paint in appearance and the high odor was the result. High dosages of Nuchar were used during October and November to assist the regular plant processes. After November, carbon was not used. The decline of the odor was rapid in November, and reached a minimum in March.

The monthly averages of daily odor determinations at another water softening plant at Springfield are shown in figure 3. Here the most troublesome period was in May. No aeration is employed at this plant except the small amount incidental to recarbonation with

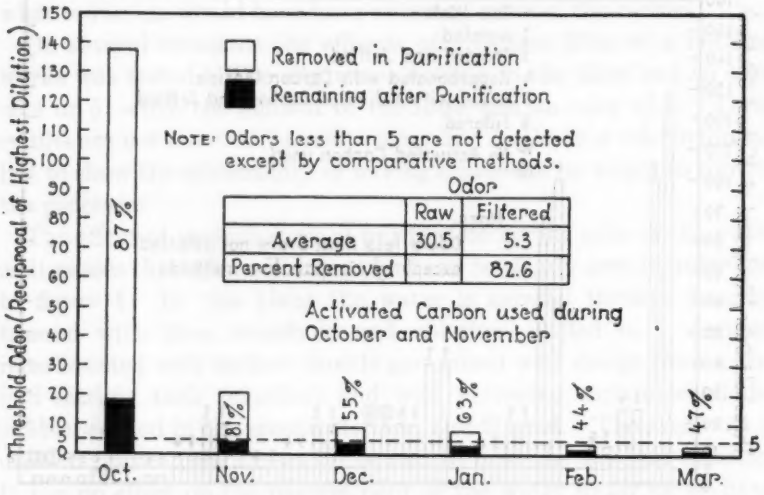

FIG. 2. ODOR REMOVAL AT A WATER SOFTENING PLANT. BLOOMINGTON, ILLINOIS. OCTOBER, 1931 TO MARCH, 1932

carbon dioxide. The raw water is treated with lime, alum, ammonia and chlorine mixed and settled. This constitutes the first stage in the odor removal process and is responsible for a reduction of 59 percent of the odor. After settling, the water is recarbonated and filtered. Activated carbon was added in the recarbonation basin where agitation was available. It was used during May and June, and gave a welcome reduction of odor amounting to about 34 and 42 percent of the total. During the balance of the time it was not used. It will be noted that the filtered water usually shows a slight improvement over the settled.

The softening process shows even better efficiency in odor removal

at Springfield than at Bloomington. This is probably due to differences in the character of odors. The Springfield raw water is from a flowing stream subject to sewage and surface contamination and frequently turbid. The Bloomington raw water is from a reservoir, relatively clear and uncontaminated. In both cases activated carbon gave a marked improvement, though not complete removal. Laboratory tests showed that small amounts of carbon were as effective as larger doses unless the dose was increased to excessive and impractical amounts.

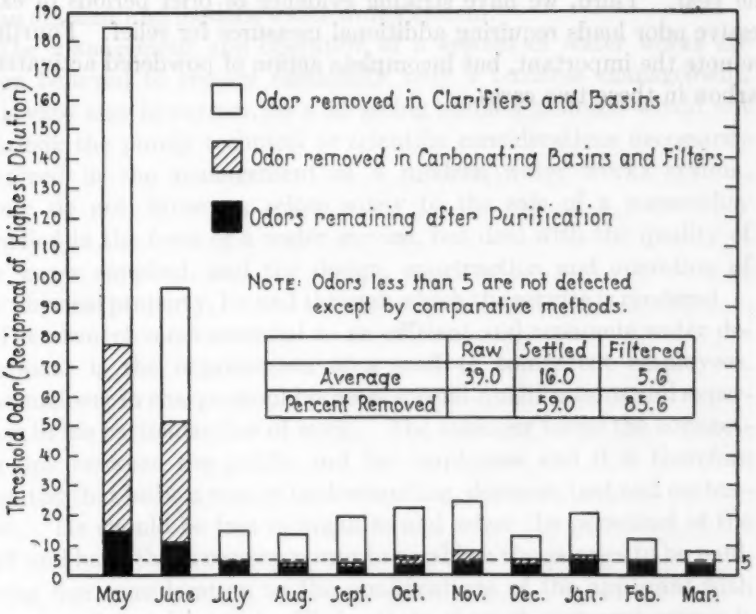

FIG. 3. ODOR REMOVAL AT A WATER SOFTENING PLANT. SPRINGFIELD, ILLINOIS. MAY, 1931 TO MARCH, 1932

It has been the purpose of this paper to point out the informative value of a method of odor measurement. It is not contended that the method used answers all the questions which arise in handling the odor problem. The quality of odor is not touched by this yardstick. One odor of 10 may be more disagreeable than another of the same numerical value. Methods of removal may be selective. taking one class of compounds and leaving another; such action would not be revealed by mere odor numbers. Taste is very fre-

quently a reflection of odor, and is roughly proportional; but not always. There are other shortcomings that may be pointed out. But the results indicate that considerable definite information is obtainable by the use of the dilution method of odor determination.

Taking these records as a whole, we can draw a number of conclusions. First, we find that the raw water at the two plants studied is unsatisfactory from the standpoint of odor most of the time. Second, we note a marked reduction of odor in the settling basins sufficient to produce a satisfactory water during the greater part of the year. Third, we have striking evidence of brief periods of excessive odor loads requiring additional measures for relief. Fourth, we note the important, but incomplete action of powdered activated carbon in these two cases.

OPERATING ECONOMIES IN WATER WORKS SYSTEMS[1]

By W. E. MacDonald[2]

Economy of design and construction is the fundamental principle of engineering which is the basis of good management in the operation of an efficient and modern water works system.

The management and operation of a system of water works are often believed to require essentially only a business management. This view may be correct, for a far seeing business manager would not overlook the purely technical or scientific considerations necessarily involved in the management of a modern water works system. These do not, however, relate solely to the sale of a commodity supplied in the form of a water service, but deal with the quality of the water supplied, and the design, construction and operation of the physical property, by and through which the service is rendered.

The element most essential to an efficient and economic water department is the organization of a staff of competent employees. The engineer in charge should possess special qualifications and experience in his particular line of work. The manager forms the connecting link between the public and the employees and it is therefore essential that he be a man of understanding, decision, tact and enthusiasm. He should be free to organize and select the personnel of the staff and have the necessary power to establish the salaries to be paid, giving due consideration to the qualifications of the applicant with respect to the position to be filled. Only through such authority is it possible to operate the department economically and promote efficiency. When vacancies occur, these positions should be filled as far as possible from the ranks of the existing personnel, affording employees an opportunity to qualify for promotion, as a result of transfers, dismissals and resignations. The employees soon realize the benefits to be gained from such a system and a keener interest in their work results.

The problem of water works management is to secure a vision of

[1] Presented before the Canadian Section meeting, March 11, 1932.

[2] City Water Works Engineer, Ottawa, Can.

the possibilities and organize the department with a view to placing it in the first rank of leadership in the city which it serves. The efficient manager will solve all needs by selecting competent heads for the different divisions and then lean heavily on them. In this way the chief executive is relieved of a multitude of details and left free to think and plan along broad constructive lines.

The planning of a water works system both in the original form and also as to improvements looking to greater efficiency and more production is a matter that must take into consideration not only immediate results, but also the requirements of the future when growth and extension of the municipality will call for greater facilities. Too often public money is expended with a view to curtailing present costs on works without first having a proper perspective of the ultimate needs of the community. In such instances, by judicious forethought it would be advisable with a view to future economies to spend more. This is the fundamental basis of town planning, and having regard to the increased cost of construction the principles and economics of town planning with particular reference to water works engineering should be studied comprehensively, for much may be accomplished thereby.

PUMPING STATIONS

In recent years many factors have largely been responsible in changing the trend of pumping practice. Probably one of the most important changes wrought has been the introduction of the centrifugal pump which has become a serious competitor of the reciprocal steam engine driven type.

The extended use of electricity has witnessed the installation of electrically driven centrifugal pumps as an economic and convenient means of handling large and small quantities of water under almost every conceivable condition.

When selecting pumps from an economic and efficiency standpoint, great care must be exercised to ensure that the pumping units are of proper design to meet exactly the individual operating conditions with respect to delivery and head.

The use of the centrifugal pump has introduced a number of problems that are of prime interest in design and operation. The centrifugal pump is less flexible in operation, for it does not as easily meet the consumption demand which varies from hour to hour. This is particularly true of the motor driven pump whose use is increasing

rapidly, because of the usually dependable electric service at reasonable rates that has been made available by the public service corporations.

As the electric service that is available in many cities is satisfactory, and as the centrifugal pump characteristics do not always permit that type of equipment to be used in a convenient or economical manner, consideration has been given by engineers to the use of motor driven reciprocating pumps.

In an endeavour to vary the delivery of a centrifugal pump so as to meet a changing demand or output, various expedients are resorted to:

(a) The use of a steam turbine.
(b) A variable speed induction motor.
(c) Additional pumps of similar and varying capacities.
(d) Oil engines.

The various methods referred to above for obtaining flexibility of output either increase the cost of installation or of maintenance over what it would have been if it were possible to operate efficiently with a more constant delivery.

In municipalities where the water supply is secured from the operation of motor driven centrifugal pumps it has been found that the use of elevated storage tanks properly located will effect a considerable saving in operating costs at the pumping station by permitting a more uniform rate of discharge from the contrifugal pumps over the twenty-four hour period.

The use of well designed and properly constructed elevated storage tanks while effecting a reduction in operating coats will in addition result in

(a) The maintenance of more uniform pressures.
(b) Reduction in capital expenditure in pumping equipment and distribution system.
(c) The maintenance of pressures during power failure.
(d) Improved fire service.

DISTRIBUTION SYSTEM

In the past less care was used in the construction of the distribution system than was exercised in any other part of the water works system. This may have been due to the fact that the work was soon covered and out of sight, or from previous lack of experience in good construction practice. Whatever the reason, it has often resulted in

the possibilities and organize the department with a view to placing it in the first rank of leadership in the city which it serves. The efficient manager will solve all needs by selecting competent heads for the different divisions and then lean heavily on them. In this way the chief executive is relieved of a multitude of details and left free to think and plan along broad constructive lines.

The planning of a water works system both in the original form and also as to improvements looking to greater efficiency and more production is a matter that must take into consideration not only immediate results, but also the requirements of the future when growth and extension of the municipality will call for greater facilities. Too often public money is expended with a view to curtailing present costs on works without first having a proper perspective of the ultimate needs of the community. In such instances, by judicious forethought it would be advisable with a view to future economies to spend more. This is the fundamental basis of town planning, and having regard to the increased cost of construction the principles and economics of town planning with particular reference to water works engineering should be studied comprehensively, for much may be accomplished thereby.

PUMPING STATIONS

In recent years many factors have largely been responsible in changing the trend of pumping practice. Probably one of the most important changes wrought has been the introduction of the centrifugal pump which has become a serious competitor of the reciprocal steam engine driven type.

The extended use of electricity has witnessed the installation of electrically driven centrifugal pumps as an economic and convenient means of handling large and small quantities of water under almost every conceivable condition.

When selecting pumps from an economic and efficiency standpoint, great care must be exercised to ensure that the pumping units are of proper design to meet exactly the individual operating conditions with respect to delivery and head.

The use of the centrifugal pump has introduced a number of problems that are of prime interest in design and operation. The centrifugal pump is less flexible in operation, for it does not as easily meet the consumption demand which varies from hour to hour. This is particularly true of the motor driven pump whose use is increasing

rapidly, because of the usually dependable electric service at reasonable rates that has been made available by the public service corporations.

As the electric service that is available in many cities is satisfactory, and as the centrifugal pump characteristics do not always permit that type of equipment to be used in a convenient or economical manner, consideration has been given by engineers to the use of motor driven reciprocating pumps.

In an endeavour to vary the delivery of a centrifugal pump so as to meet a changing demand or output, various expedients are resorted to:

(a) The use of a steam turbine.
(b) A variable speed induction motor.
(c) Additional pumps of similar and varying capacities.
(d) Oil engines.

The various methods referred to above for obtaining flexibility of output either increase the cost of installation or of maintenance over what it would have been if it were possible to operate efficiently with a more constant delivery.

In municipalities where the water supply is secured from the operation of motor driven centrifugal pumps it has been found that the use of elevated storage tanks properly located will effect a considerable saving in operating costs at the pumping station by permitting a more uniform rate of discharge from the contrifugal pumps over the twenty-four hour period.

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much trouble and needless expense, breaks occurring at the most inopportune time, resulting many times in heavy property damage and loss of life.

When excavating preparatory to installing water mains, proper supervision will prove a great saving to a community. If the work is fairly extensive, then by far the most economic way of excavation is by using trenching machines. A very few of these will accomplish much more work at a greatly reduced rate than it is possible to do by hand, but when it is required to excavate only a short section of trench then the manual labor is cheaper, as the cost of moving and setting up the trenching machinery would overcome the difference in actual cost of excavation.

Proper appurtenances are a great necessity for economical excavation. For instance, where it is necessary to cut a pavement or hard macadamized surface, it has been found that the cut can best be made with pavement breakers operated by compressed air. The air compressor is one of the most useful appurtenances in the possession of the water department as it solves many difficult works within a minimum of time.

It is false economy to attempt to accomplish work by the use of antiquated machinery or tools and the water department will find that by maintaining all appurtenances and tools in first class condition the work can be accomplished within a minimum of time at a greatly reduced cost.

When excavating the trench prior to pipe-laying it will be found much more economical to make plenty of room for working conveniently around the pipe. In this way much time is saved in the actual laying of the pipe and will allow for proper backfilling where the material will slip past the pipe and fill the lower section beneath it. If the trench is cramped for width, then the backfilling material is likely to arch and rest on the top of the pipe, causing an undue strain and possible breakage.

Main extension

Main extensions of existing works are called for from time to time to provide for the constantly increasing demands of a community and those additions to a system often require careful study. In some instances the extensions are made in accordance with a pre-arranged scheme evolved by the engineer responsible for the original design; in others, the matter is left to the discretion of the board or commission

in charge of the works. In the latter case it not infrequently happens that little or no regard is given to the possible future demands or to the requirements for fire protection, with the results that many distribution mains soon prove inadequate, particularly for the latter purpose. It is therefore advisable when planning extensions to give proper study to the community to be served so that the money expended will adequately provide for domestic and fire service in future years.

Installation of pipe

Cast iron pipe is practically the universal pipe used in all water distribution systems. In making extensions to the distribution system considerable economy can be secured in the smaller sizes of pipe by adopting the use of the 16-foot length of pipe and thereby lessen the number of joints in the pipe line, reducing the cost of labour and jointing materials.

Where lead is used for making the joints most municipalities have adopted the use of jack hammers and compressed air for caulking of all joints. This method of caulking is far superior to the former practice of caulking by hand. It speeds up the work and produces a much better quality of joint at less than 25 percent of the former cost.

In recent years it has been possible to effect savings in the installation of pipes in the distribution system by the adoption of one or more of the many lead substitutes or jointing compounds. These jointing materials greatly decrease the cost per joint in entirely eliminating caulking and making it possible to install the cast iron pipes successfully without the necessity of providing additional excavation areas at bell holes as formerly required for caulking of joints. Records taken recently on the installation of a short line of 36-inch cast iron pipe in this city showed that the cost of completing the joints with lead was $18.06, whereas the same joints were completed by the use of one of the jointing materials at a cost per joint of $4.42, thus showing a saving per 100 feet of pipe installation of $109.12, plus the additional saving effected in the lesser quantity of material required to be excavated.

As against this saving in initial cost of main laying the engineer has to carefully consider the many merits of the use of lead as a jointing material. The use of lead permits of greater flexibility in the pipe line than most of the jointing compounds. During the past summer this fact was very noticeable during the excessively dry period owing

to the shrinkage of the earth. We experienced more than twenty fractures through the transverse section of the pipe immediately adjacent to the old time rigidly made spigot and faucet joint.

The past summer witnessed the greatest number of fractures in our distribution system during the past twenty years and it is a matter of record that not one break occurred in close proximity to a lead caulked joint.

Maintenance of system

Economy in the operation and maintenance of a public water supply requires that a reasonable amount of care should be exercised by the officials and employees to avoid any accident, due either to natural causes or neglect, which would impair the efficiency of the works or inconvenience consumers. Under favorable conditions the amount of care or supervision may be comparatively small, but usually considerable vigilance on the part of those in charge is required at times to maintain the system in good condition.

If economical administration of a water department is to be obtained then it is necessary for the engineer to give considerable attention to the following appurtenances of the system: Inspection and maintenance of fire hydrants, gate valves and meters, prevention of electrolysis, regular and systematic survey for detection of leaks, thawing of frozen services and finally, the efficient handling of all general and emergency repairs to the system throughout the twenty-four hours each day.

Water waste

At the present time the problem of reducing the waste of water which invariably occurs in all unmetered cities and towns, is receiving an amount of attention from engineers and water works officials equal to that formerly given to the problem of securing additional supplies, when the demands for water tend to exceed the quantity available.

The present sanitary requirements that water supplied for domestic consumption shall be free from disease-producing organisms necessitates in many cities the construction and operation of highly efficient water purification plants. The cost of maintenance of such plants is in most cases highly expensive due to the huge amount of chemicals required to complete the process of purification and sterilization.

The cost of operation of a purification plant is in direct relation to the quantity of water treated and it is vitally important, if the

water charges are to be maintained at an equitable rate, that a rigid system for the prevention of water waste be strictly enforced.

The records of consumption in various cities and towns indicate that the amount of water wasted often far exceeds the quantity necessary to satisfy the demands of health or convenience. This waste results largely from the failure of the majority of consumers to appreciate the value of a supply of pure water. The installation of plumbing fixtures of inferior grade, the failure to maintain pipes and fittings in good repair, and carelessness in the use of water impose an unnecessary burden on the system. A continuation of this practice entails increased expenditures for additional supplies, extensions to the distribution system, pumping equipment and purification plant, with a corresponding increase in the annual expenditures for maintenance and operation.

A large proportion of the waste of water is preventable, especially that portion which has its origin in the erroneous belief of many consumers that water is free, and therefore, to be used without regard to economy. This extravagant waste of the supply is due to the custom of many consumers allowing the water to run freely in the summer that the water may be cool for drinking and in the winter to prevent the pipes from feezing. In many Canadian cities this latter practice of running water to waste to prevent freezing is quite common, but should not be accepted or tolerated in any city as a solution of the cold weather problem of freezing.

Several years ago the City of Ottawa was confronted with this situation of the peak load occurring during the winter months and action was immediately taken to institute a system of inspection and the gradual enforcement of insulation of all pipes and fittings to prevent freezing. The efficacy of this system has been great as demonstrated by the fact that during the past five years we have been successful in reducing the average winter consumption by more than two million gallons.

Waste water surveys

The determination of underground leaks and their ultimate repair is a work which demands the fullest attention of all water works. There is no branch of the service which will pay larger dividends towards securing a more economical administration of the water department than will the work of a properly functioning waste water survey division.

Water meters

All activities of the water department which endeavor to bring about a reduction of waste of water can be highly commended as an economical measure; but of all means inaugurated by the engineer for the conservation of water there is none as effective as the installation of meters.

Usually much opposition is raised to the introduction of meters, but after they have been placed in service the results are commonly such as to cause them to be greatly favored by the community.

Many pages could be written on the savings effected in hundreds of American and Canadian cities by the universal adoption of the metered system. Wherever meters have been installed, whether the system is partially or wholly metered, there has been a marked reduction in the water delivered, with no appreciably reduction in the legitimate use of water.

The supply of water is not a fixed service, like police and fire protection, organized to an extent dependent only upon the amount of population, but is a service varying according to the amount of use. Therefore, that part of the use over and above the minimum required for the proper health and sanitation of the community is a cost correctly chargeable to the individuals responsible for waste and should be collected from them and not from the general consumers.

To carry out a meter program successfully I would suggest the building up of an organization as a separate branch of the service whose duty it is to test, install, read, repair and systematically record the individual performance of all meters. The records kept by this branch of the service will prove of inestimable value to the officials of the department in properly administering its affairs in selecting and purchasing the highest quality of meter and, in addition, allowing the water department to maintain an accurate check on all services, so that the water works department is assured of all income justly due.

The systematic and energetic program for the reduction of waste carried on in the City of Ottawa during the past few years has been the means of reducing the amount of water pumped daily by more than 65 gallons per capita. This reduction in itself represents a direct saving in the cost of chemicals and sterilizing agents of $26,000 per year, plus the saving effected in capital expenditures in eliminating the necessity for the enlargement of the purification plant, pumping equipment and distribution system.

Incidentally, for every one gallon reduction in the per capita consumption, the City of Ottawa is able to effect a saving of $400.00 per year on the cost of chemicals alone.

Thawing of frozen services

Until a few years ago, probably one of the most vexing questions confronting the officials of a Canadian water department was the frozen service. For instance, there have been winters in Ottawa when services of more than three thousand consumers have been frozen and the department in years past were unable to cope with this situation in a satisfactory manner. This matter required serious study, so in 1919 we discontinued thawing services by the former unsatisfactory transformer method and designed and constructed four self-contained electric thawing apparatuses. The success of these new machines has been truly marvelous in rendering a prompt and efficient service as well as having reduced the cost of each thawing operation from $6.05 per service to $1.78 per service, effecting an individual saving of $4.27 per service. Allowing for all operating costs, interest and depreciation, the thawing machines have been directly responsible in effecting a saving of over $30,000.00 to date.

Inspection of supplies

It is very desirable to have all castings, pipe, valves, etc. inspected during manufacture. In the case of castings and pipe any flaws that may exist would be detected previous to the pieces being coated, flaws that might otherwise pass unnoticed until the piece had been installed and failed under working conditions. Had the faulty piece been rejected at the factory a great deal of labor, money and time would have been saved. In the case of valves, any imperfection in the parts would be detected and the piece rejected or adjusted with a consequent saving in freight bills and time. In all cases, the knowledge that the material has passed a rigorous inspection during manufacture means much to those who are responsible for the installation and maintenance of the system of which it will form a part.

CHEMICAL SUPERVISION

A well qualified and alert chemist is of inestimable value in a water purification plant. By maintaining close watch on the effluent of the plant, he can so adjust the chemical treatment as to guard

against tastes and odors and can so control the pH of the water as to prevent red water trouble. In addition to insuring a satisfactory effluent at all times, he would be able to save considerable money by seeing that just sufficient and no more, chemicals are applied. He would also continually strive to improve on the plant's past performance by keeping in close touch with the latest developments in the water purification field and by research work in his own laboratory.

WATER SOFTENING

Water softening constitutes another large saving, not necessarily to the water department, but to the consumers.

The difference in cost between producing water satisfactorily soft as against the cost for water and desirable for drinking purposes only, is so small when distributed over the entire population of a community, and the advantages of soft over hard water are so evident that many municipalities are now taking steps to install a water softening plant.

The losses due to hardness may be classified as follows:

(1) Extra cost of soap and other preparations for softening water.
(2) Extra expense of cisterns and double plumbing systems.
(3) Effects on fabrics.
(4) Heat losses in hot water heaters and boilers.
(5) Extra expense for operating steam boiler plants.

In addition to the above, numerous industries require soft water, a few of which are:

(1) The paper industry, which would destroy large quantities of sizing chemicals by using hard water.
(2) The tanning industry, in which the use of soft water prevents the formation of soap curds which are difficult to rinse from the wool.
(3) Ice manufacturer who are able to manufacture a satisfactory quality of ice from softened filter water.

Manufacturing interests will be more easily induced to locate in cities having soft water, other things being equal, than in locations having a hard water supply. The added comforts which the citizens will experience by the change from hard to soft water cannot be fully appreciated until after the change has been made.

The saving in soap alone to a community will pay for all costs of softening.

A number of interesting figures have been given to emphasize the economic importance of soap waste due to hard water.

One gallon per capita per day is usually taken as the amount of water used for washing. On this basis it was reported that the removal of 72 p.p.m. of hardness from the water of the City of St. Louis resulted in a saving of $920.00 worth of soap per day. It is estimated that in a town of 40,000 inhabitants using a water of 300 p.p.m. hardness a ton of soap is wasted per day.

In connection with the problem of wager softening I am indebted to Dr. A. E. Berry of the Department of Health, Toronto, whose office has on file much valuable data on this most interesting subject.

COST OF WORKMEN'S COMPENSATION

In recent years, and in particular since the unemployment situation became so acute, there has been a steady increase in the cost of compensation on all city works. Undoubtedly a great deal of this increased cost is directly due to the employment of many men unskilled in this particular branch of the service.

During 1931 the City of Ottawa was required to pay compensation to 160 workmen who were injured from time to time in the public service an amount in excess of $9,800.00.

In November, 1931, with a view to reducing the number of these claims, we organized a first aid bureau with a competent instructor in charge who held regular classes twice weekly, teaching a course of instruction in first aid and accident prevention to all foremen, sub-foremen and timekeepers. In addition to these classes the instructor each day visited the various works, addressed the workmen at convenient times and pointed out to the foremen the presence of many accident hazards. The general results so far obtained from this accident prevention policy inaugurated by the department clearly show a very substantial reduction in the number of compensation cases. It is my belief that the policy adopted to reduce accidents has already shown that considerable money can be saved annually and that much suffering and loss of time on the part of the workmen can be avoided.

COST ACCOUNTING

There is no problem in municipal operations more important than the adoption of a thorough system of accounts through which a full and comprehensive report of the municipality's financial condition

may be determined at any time. The cost accounting system should be such that it renders easy comparison of unit costs and makes it possible to exercise greater efficiency and economy in extending and operating the system.

By means of uniform cost accounting records one is enabled to tabulate the various costs of maintenance and construction works, from which an analysis at any time will disclose the foremen who are producing the best results and thereby allow the elimination of the less desirables. This information will permit of more accurate estimating by the engineering staff and will result in lower costs, which in itself will more than compensate for the cost of maintaining a unit cost system.

Bureau of purchases and supplies

By instituting a bureau of purchases and supplies substantial savings in the purchase of these materials could be effected. Requisitions for goods from time to time are made to the purchasing officer in charge of this division. By planning the work, where possible, well in advance, purchase can be made in quantities. When advantage is taken of the low prices prevailing during certain periods when the manufacturers are over-stocked, substantial savings may be effected, provided adequate and well located storage space has been provided for.

CONSTANT SUPERVISION

To insure that the service of the department is efficiently maintained at all times during the twenty-four hour period we have inaugurated in Ottawa, a central headquarters bureau. The purpose of this office is to coördinate all the various branches of the water department. At this office all complaints are received and the officer in charge is continuously informed of the working of the entire department, receiving hourly readings of gauges from the pumping stations, transformer stations and filtration plant, as well as pressure gauge readings from all city fire stations. This office is equipped with fire alarm going, automatic pressure gauge and furnished with a complete set of plans and blue prints of the entire distribution system, giving exact location of all mains and valves.

Emergency service is a most important part of the water department's responsibility in safe-guarding the lives and property of the citizens, and the City of Ottawa has placed this service directly

under the central headquarters office. To meet this situation we have specially trained employees operating two emergency trucks completely fitted with all supplies and appurtenances.

SUPERANNUATION

In the operation of the Water Department, like all other large business concerns or institutions, a time comes when many employees, who, after faithfully serving the department for many years, reach an advanced age when it is no longer possible to carry on the arduous duties of the department. In such instances it is not the desire of the officials in charge to discharge such employees with many years of faithful service, yet in many cases permitting them to continue in the public service slows down the work of the department and prevents the inauguration of more advanced and efficient methods.

To provide for this condition in the public service the City of Ottawa, in September, 1931, adopted a permanent form of superannuation, the purpose of which is to provide an annual pension to the employee on reaching a retirement age, or in the event of death to provide for the widow and dependents.

The effect of this scheme to date has clearly shown that the passing of this superannuation by-law has resulted in mutual advantage to both the employee and the corporation. The workman has become more contented and has taken a new interest in his daily work. He hesitates to jeopardize his position in any way and lose the benefits of the superannuation fund. On the other hand, the water department is now for the first time in history able to take care of successfully its employees advanced in years by providing a pension. The retirement of many of the older employees, the combining of one or more positions and the promotion of younger men in the service has resulted in considerable economies, in addition to advancing the standards of the department along more scientific and advanced methods.

WATER HAMMER AND SURGE TANKS[1]

By A. W. F. McQueen[2]

This paper discusses certain phases of the general problem of the regulation of long water columns as found in water works practice. This control must be exercised to prevent pressure changes occurring of such a magnitude that there may be danger of rupture of pipes, valves, centrifugal pump casings, etc. The pressure changes that are being considered are ordinarily known as water hammer and result from any rapid variations in the amount of water flowing in a pipe or conduit. Only those pressure changes will be treated that occur either in the delivery pipe from a motor-driven centrifugal pump or in the closed suction pipe to such a pump as the result of a complete stoppage of the power supply.

Water hammer has been known for many years. In the ordinary water works distributing system, water hammer pressures, due to any rapid variation in the flow, have been taken care of by the use of pipes of certain sizes and strengths that have been developed as a result of actual practice extending over a number of years. However, where the pumping-station for a large city is remote either from its source of supply or from the distributing system connected with it, conduits of large size must be used, and for economic reasons, velocities must be maintained at a high value. Such conduits must be carefully designed, since the water supply of the community they serve is usually dependent on them. On the other hand, they are likely to be expensive. Therefore any possible measure that may reduce water hammer effects must be carefully investigated so that the amount of material employed in fabricating the pipe may be reduced to the smallest amount consistent with safety.

The classic paper in the English language on the subject of water hammer appeared in the Proceedings of the American Water Works Association in the year 1904 and consisted of a digest by Miss O.

[1] Presented before the Canadian Section meeting, March 9, 1932.

[2] H. G. Acres and Company, Ltd., Consulting Engineers, Niagara Falls, Canada.

Simin of a paper by Professor Joukowsky, which was presented before the Imperial Academy of Science at St. Petersburg in 1898. This paper by Professor Joukowsky gives a theoretical mathematical analysis of the problem, together with the result of an extended series of experiments which were carried out at Moscow in the years 1897–98 Miss Simin's digest explains the principles involved, gives the principal formulas and describes the experiments together with the conclusions deduced from them. Since Professor Joukowsky's paper was published, the subject has been developed and extended to cover a wide range of conditions. Chief among the succeeding writers on this subject, whose work has been published in English, may be mentioned L. Allievi, N. R. Gibson, R. D. Johnson and S. L. Kerr.

The mathematical treatment, as presented by these writers, is not an easy one to follow and is full of pitfalls for the unwary and inexperienced. No attempt will be made to give this mathematical analysis here and the interested engineer is referred to the appended bibliography.

THE PHENOMENON OF WATER HAMMER

The description of water hammer has usually been presented by considering the sequence of events following the instantaneous closure of a valve at the downstream end of a long pipe containing water under pressure. This is probably the easiest manner by which the subject can be introduced and such a condition will first be analysed here.

A long column of water travelling at a high velocity possesses considerable kinetic energy and if an attempt is made to stop the flow suddenly, this kinetic energy must be expended in some fashion. The only way in which this can be done is by compressing the water and expanding the pipe (if the latter possesses elasticity). This compression of the water and expansion of the pipe begins at the valve, which has been closed instantaneously, and travels upstream. The rate of travel is determined solely by the bulk modulus of elasticity of water, the diameter of the pipe, the modulus of elasticity of the material of which the pipe is made and the thickness of the pipe. It is entirely independent of the velocity of the water. If the pipe were absolutely rigid and could not be expanded at all, the velocity of this pressure wave would be the velocity of sound waves in water, viz., 4675 feet per second. When this wave of increased pressure reaches the upstream end of the pipe, which, for the purposes of this

illustration, may be considered as an open reservoir, the entire volume of water in the pipe is compressed, the pipe has been expanded and the velocity throughout the pipe reduced to zero. In other words, the original kinetic energy of the water has been transformed into elastic deformation of the water and of the pipe materials. It is evident that such a condition is not stable, and, due to the fact that water in the pipe is now at a higher pressure than the water in the reservoir, water will commence to flow from the pipe into the reservoir,

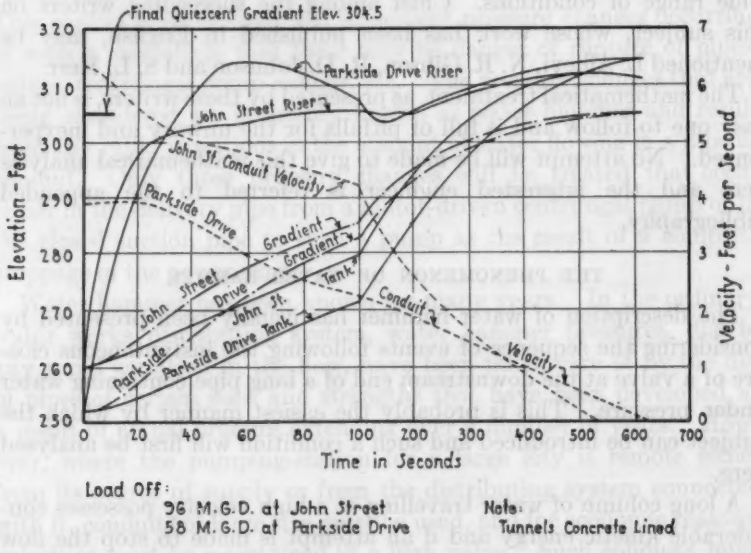

FIG. 1. SURGE TANK STUDY. TORONTO DUPLICATE WATER WORKS SYSTEM

the pressure of the water will return to its original value and the pipe will contract also to its original condition. This return to the original water pressure and pipe diameter proceeds from the upstream end of the pipe to the downstream end with the same velocity as the wave of compression that was mentioned above. At the completion of this second stage of the phenomenon the water has resumed its original pressure and the pipe its original size, but the water itself is now travelling in the reverse direction with a velocity equal to that at which it was travelling from upstream to downstream just previous to the closure of the valve. The conditions are exactly the same as at the instant of closure, with the exception that the direction of

flow is reversed; consequently, a wave of subpressure is initiated at the valve, the pipe contracts yet further, and this condition of subpressure and further contraction of the pipe travels upstream with the same velocity as previous waves. At the instant that the water in the pipe throughout its entire length has been reduced in pressure and the entire pipe contracted and the velocity again reduced to zero, the kinetic energy of the water has again been changed to elastic deformation. This, of course, is still an unstable condition and water will begin to flow into the pipe again, the pressure will increase to its original value and the pipe expanded to its original diameter. When the entire pipe and water column have thus been affected, there is a return to the condition that existed just prior to the closing of the valve.

This phenomenon is repeated again and again in the order that has been described and the succession of pressure changes from normal to excess pressure, through normal to subpressure and back again to normal, with the accompanying changes in pipe diameter, is known as water hammer. A diagram showing these pressure changes in various stages and a time history of the water hammer wave at various points along the pipe is given in figure 1. The arrows with the wavy shaft represent the direction of the water hammer wave, while those with straight shafts represent the direction in which the water is travelling.

The velocity of wave propagation, a, is given by the formula:

$$a = \frac{4675}{\sqrt{1 + KB}} \tag{1}$$

where K equals the ratio of the elastic moduli of water and the materials of the pipe shell and B equals the ratio of the diameter of the pipe and the thickness of shell. The pressure rise, p, is given by the formula:

$$p = \frac{avw}{144\,g} \tag{2}$$

where p equals the change in pressure in pounds per square inch, v equals the velocity of the water in the pipe prior to closure in feet per second, w equals the specific weight of water in pounds per cubic feet, and g the acceleration, due to gravity, in feet per second per second.

So far there has only been considered the change in pressure that occurs, due to the reduction of the velocity from some value, v, to zero. If the reverse of this takes place, that is, an increase in the velocity from zero to some fixed value, v, then a cycle of events, similar to that which has been described, but starting with a wave of subpressure, will be produced. Formula (2), however, is not limited to these conditions and in its differential form, that is,

$$dp = \frac{aw\ dv}{144\ g} \tag{3}$$

can be used for any changes of velocity whatsoever, that is, a partial closure of the valve at any position or a partial opening of the valve at any position.

The time taken for the velocity wave to travel from its point of origin to the reservoir and back again is evidently equal to

$$t = \frac{2\ L}{a} \tag{4}$$

where L equals the length of the pipe from valve to reservoir. If the time of valve movement is not instantaneous the resulting phenomena may be visualized by considering the valve to be closed by a succession of instaneous short movements. Each movement will produce a water hammer wave and the total water hammer effect may be computed by the algebraic addition of the water hammer pressure of each wave. If the time of operation of the valve is less than t, the maximum water hammer produced may be calculated by formula (2). On the contrary, if the time of operation of the valve is greater than t, the first water hammer wave will return to the valve and be reflected there as a wave of subpressure, before the valve has ceased its movement. Consequently, the net water hammer effect can only be calculated by successive applications of formula (3), keeping track of all reflections as they are produced and adding algebraically each increment of pressure as it occurs at the point under consideration. The net water hammer produced under these conditions is always less than the maximum water hammer given by equation (2) and, moreover, the decrease in net water hammer is a direct function of the time of closure; that is to say, the longer the time taken to operate the valve the smaller will be the resulting water hammer effect.

The phenomenon of water hammer has been described in its simpplest aspect and if there are branches in the pipe having dead ends, then the excess pressure on entering these branches will be reflected at the dead ends and the final rise in pressure will approach a value approximately twice that given by the methods above. If these branches are further subdivided into additional branches with dead ends reflected pressure waves of extremely high intensity may result. In addition, if the above description has been followed clearly, it is evident that as far as the upstream end of the pipe is concerned, the reflection of the pressure wave there is the result of a difference in pressure between the water in the pipe and that in the reservoir. Consequently, if there is any condition in the pipe itself, such as would give rise either to a change in the value of, a, the velocity of wave propagation, or in the value of, v, the velocity of water in the pipe such that the product, av, is not constant, then as the water hammer wave travels up and down the pipe the value of, p, the water hammer pressure will also vary. Where such a condition obtains at any point, there is a variation in p. Such a point will constitute a place where a partial reflection of the pressure wave will occur. Such partial reflections, it is known, are able to travel up and down the pipe unaffected by any other pressure waves, so that the true changes in pressure at any point can only be given by the algebraic addition of each of the pressure changes due not only to the primary pressure wave but also to all secondary waves. It is at once seen that such a condition is exceedingly complex and under certain conditions the maximum water hammer effect that may occur will even exceed that given by formula (2).

APPLICATION OF THE THEORY TO WATER WORKS PRACTICE

The case of a centrifugal pump supplying water to a long pressure conduit will first be considered. The condition that has to be provided for is that of total loss of power and hence the cessation of pumping. A water hammer wave of subpressure is immediately started at the pump and travels towards the reservoir, tank, or other outlet, where it will be reflected. The cycles of changes that takes place is exactly similar to that which was described above, except that the phenomenon commences with a wave of subnormal pressure instead of a wave of supernormal pressure. If the pump may be considered to slow down sufficiently so that it pumps no water at all before a time equal to t, then a wave of supernormal pres-

sure caused by a reversal of flow in the pipe will be produced, which may approach the maximum water hammer. This pressure may be so great as to rupture the pump casing. To protect the pump against this condition it is customary to install a stop-and-check valve on the pressure side of the pump, so designed that it will either close on reversal of flow, or begin to close on loss of power to the pump and with the rate of closure so timed that the moving part of the valve becomes seated at the instant the reversal of flow takes place. While such a device provides adequate protection for the pump, it does nothing to limit water hammer pressures in the pipe line and these, as stated above, may approach maximum water hammer.

In the case of a check valve operated by reversal of flow, these pressures will be produced with shock intensity. Therefore, the materials from which the pipe is made must not only have adequate strength, but also must be selected with care in order that they may be sufficiently ductile to prevent rupture from occurring at high pressures.

If the pipe line is very long, then it becomes an expensive matter to provide sufficient material of a suitable nature to take care of the water hammer pressures. To obviate this expense, one of several methods may be employed. A very common method is the provision of an air chamber of suitable size connected to the pipe just downstream from the valve. Such air chambers will relieve the water hammer effect and prevent damage. In order that the successful operation of these chambers may be relied upon at all times, it is necessary to keep the volume of air in them between very definite limits. Losses that occur due to absorption of air by the water and by leakage of air through the walls of the chamber must be constantly replenished from an outside source. This is their chief disadvantage.

Relief valves, either spring-operated or mechanically-operated, have also been employed to relieve water hammer. They are water-wasting devices, and, from a mechanical viewpoint, can never be said to give satisfaction.

Surge tanks

A standpipe or a Johnson differential surge tank connected to the delivery pipe as close to the pump as possible will form a very effective means of reducing water hammer wherever conditions permit the use of such a device. The topography of the ground in the immediate

vicinity of the pumping-station must be suited to pumping pressures so that the cost of standpipe or surge tank may come within economic limits. Which of these two structures should be used in a particular case will depend entirely on the length and size of the force main, the maximum quantity of water it is likely to carry, the pressures pumped against, and the amount of friction loss in the main. Where a surge tank is indicated, it would have a dual rôle. Besides the function just described, it would serve as reserve storage and either supplement or replace part of the reserve storage that would normally be installed near the high-value district.

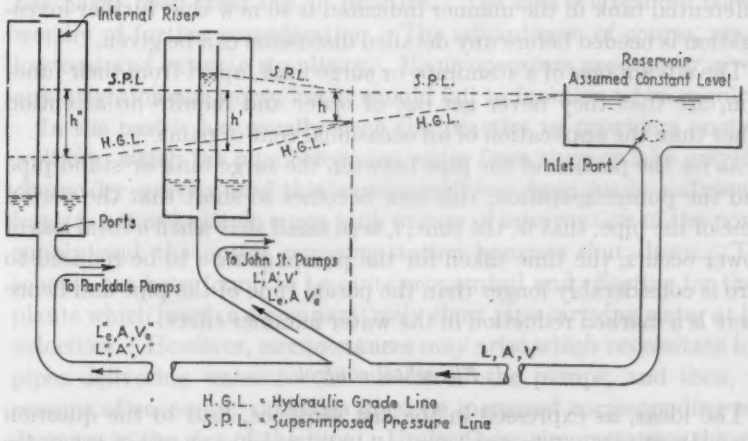

FIG. 2. SCHEMATIC LAYOUT, TUNNEL AND SURGE TANK—TORONTO DUPLICATE WATER WORKS SYSTEM

The differential surge tank was invented by R. D. Johnson. It differs from a simple tank only in having an internal pipe or riser, as shown in figure 2. At the base of the internal riser, port openings are provided, communicating with the tank. The area of these port openings is proportioned to suit the conditions under which the tank is to operate.

When a power interruption occurs and the pumps stop, the water in the internal riser falls, establishing quickly a retarding head on the pipe line. At the same time, water from the tank flows through the ports and supplies the demand. When the velocity in the pipe has been reduced to zero (assuming no demand), the level of water in the tank and in the riser will be the same, but this level corresponds to a

lower pressure than that in the distributing system. Consequently, there will be a reversal of flow in the pipe and water will rise in the riser and spill over at the top into the tank. A retarding head is again formed, the velocity in the pipe again reduced to zero, and the surplus water has been received by the tank. This action is very quickly damped and the whole system soon attains equilibrium.

The differential surge tank has proved to be a very efficient regulator in hydro-electric practice. It is realized, however, that some of the chief functions which a surge tank has to perform in a hydro-electric installation are absent in water works practice. This may materially modify the manner in which the tank functions. The use of the differential tank in the manner indicated is so new that further investigation is needed before any detailed discussion can be given.

The advantages of a standpipe or surge tank, apart from their function, are that they never get out of order and require no attention other than the application of an occasional coat of paint.

As for the portion of the pipe between the surge tank or stand pipe and the pumping-station, this now becomes so short that the period time of the pipe, that is, the time, t, is so small that when a total loss of power occurs, the time taken for the pumpage rate to be reduced to zero is considerably longer than the period time of the pipe and hence there is a marked reduction in the water hammer effect.

Fly-wheel control

The ideas, as expressed in the last sentence, lead to the question as to whether it might not be possible to increase the time taken for pumping to cease. If a fly-wheel is placed on the pump shaft, between the pump and its motor, then the time taken for the pump to slow down under the conditions assumed can be increased to any amount that may be considered desirable, provided that such a time does not call for an impractical size of fly-wheel. Because of the high speeds at which centrifugal pumps normally operate, the amount of kinetic energy in a fly-wheel of even moderate dimensions, when rotating at pump speed, is considerable. Therefore, no trouble need be anticipated in providing a fly-wheel of sufficient size so that the time taken during deceleration of the pump could be extended to 20 or 30 seconds, or even more if desired. The water hammer effect under these conditions, for the normal length of pipe, will be only a fraction of the maximum water hammer. A valve placed at the discharge from the pump could be operated to close gradually during

the time that the pump is slowing down and be fully closed at the instant the pump ceases to supply water. The water hammer surges that will now occur will be very small and confined only to the pipe line itself. Therefore, the pipe need be designed only to take care of these comparatively small surges in pressure and a marked economy in the cost of the pipe should result. The additional cost due to the fly-wheel will, in most cases, be very small as compared with the saving due to the reduction in thickness of the pipe walls, so that the net economy effected by the use of a fly-wheel should, for a long pipe line, amount to a considerable sum.

As far as is known, the use of a fly-wheel in the manner indicated has never been tried out in practice. The idea is advanced here as worthy of further consideration. The advantages, of course, are its low cost and extreme simplicity. Plant operators need never give it any attention nor worry lest it should fail to function when required.

In the past it has usually been the practice to provide a suction-well into which the pipe conveying water from river or lake may discharge by gravity and this suction-well has been made sufficiently large to act as a simple surge tank in case of interruption of the power supply and the entire pumping-station becomes shut down. This scheme has been found to be quite economical and effective for those plants which involve a comparatively short pipe carrying water at low velocities. However, circumstances may arise which necessitate long pipes delivering water to the suction of the pumps, and then, for reasons of economy, velocities must be increased corresponding to a decrease in the size of the pipe. Under these circumstances the suction-well, due to its inherent inefficiency, will probably become extremely large and one of the several methods outlined above would be indicated, depending upon the conditions. The suction in these cases is, of course, a closed system and a stop-and-check valve will be necessary to prevent reversal of flow through the pumps. This valve could be so arranged that it will start to close when the power is interrupted and the closing time arranged so that final seating of the valve coincides with zero velocity in the pipe.

Pump suction installation at Toronto

A practical example of the use of a differential surge tank connected to pump suctions to decrease water hammer effects is found in the new extension to the Toronto Water Works System, which is now under construction. Here the scheme involves an intake and pump-

ing-station at the extreme easterly limits of the city, delivering water to filters and from thence to a clear-water reservoir in the usual fashion. A tunnel from this clear-water reservoir leads under the city in a westerly direction and traverses almost the entire length of the city, a distance of approximately 9½ miles. An offtake from this tunnel, slightly over 700 feet long, is situated approximately three-fifths of the distance from the reservoir and leads to the John Street pumping-station. The extreme westerly end of the tunnel will feed the new Parkdale pumping-station. Surge tanks are being built in connection with each of these pumping-stations to regulate the water in this tunnel. These tanks will be Johnson differential surge tanks. It is believed that this is the first application of surge tanks of this type to water works practice. The tank at John Street has an internal diameter of 30 feet and the height of the shell is 83 feet. The internal diameter of the Parkdale tank is 25 feet and the height of the shell 94.5 feet. The internal risers of both tanks have an inside diameter of 6 feet. The investigation of the action of these two tanks was complicated by the fact that they would both act in unison to control the water column in the tunnel. As such an analysis, as far as is known, has never been published before an outline of it will now be given.

Mathematical analysis of Toronto conditions

This analysis, in which use is made of the method of arithmetic integration, presents a very interesting application of two fundamental laws of mechanics, viz., the hydraulic Law of Continuity and Newton's Second Law of Motion. The following discussion, for the sake of clarity, refers only to the case of retardation at both tanks of a system provided with only two tanks. The formulas derived, however, can be applied to all cases of change in velocity, including the case of acceleration at one tank and retardation at the other, by the correct use of positive or negative signs with the various quantities. Also, an extension of the method can be used where more than two tanks are involved.

Referring to figure 2 we may write, at any instant, the differential form of the law of continuity as

$$-A\,dv = -A'\,dv' - A''\,dv'' \qquad (5)$$

using the negative sign to denote the fact that the velocity differentials act to decrease the flow. The forces causing retardation of flow are, of course, measured by the difference between the hydraulic

gradient at each tank and the elevation of the water surface in the internal riser (differential tank). Both these superimposed pressures decrease uniformly to zero at the reservoir, if all branches of the conduit system have the same area. If the various branches have not the same area, they may be replaced by hypothetical conduits having the so-called "equivalent lengths" corresponding to one uniform area throughout the system. In the following, the area "A" has been taken as this uniform area. The equivalent lengths are, therefore,

$$L_e' = \frac{L'A}{A'}$$

$$L_e'' = \frac{L''A}{A''}$$

Equation (5) can now be re-written as

$$-dv = -dv_e' - dv_e'' \tag{6}$$

By the use of Newton's Second Law of Motion, the following equations may be written,

$$-dv_e' = \frac{g}{L_e'}(h' - h)\,dt \tag{7}$$

$$-dv_e'' = \frac{g}{L_e''}(h'' - h)\,dt \tag{8}$$

$$-dv = \frac{g}{L}h\,dt \tag{9}$$

where the quantities $(h' - h)$, $(h'' - h)$ and h represent the net retarding force on each of the three water columns. The action of the two tanks will, of course, be such that the superimposed pressure at the junction of the two branches of the conduit will be the same, whether this pressure is calculated as due to the superimposed water column in the internal riser of one tank, or of the other. The division of flow between the two branches will continually adjust itself so that the amount of water flowing into each tank, taken in connection with the physical dimensions of that tank, will cause the relative levels of water in the two risers to assume such values that the pressure distribution in the conduits must be such as has been described. Any tendency toward a departure from this balance is self-corrective.

Thus, let it be assumed that there is a tendency in tank No. 1 for the water to rise above this "balance" level and that it does so rise. There must, of necessity, be a corresponding rise in pressure at the junction of branch No. 1 greater than that at the junction of branch No. 2. This pressure increase will travel as a pressure wave along branch No. 2 towards tank No. 2, decreasing as it does so, the *rate* at which the flow in that branch is being retarded. The net result

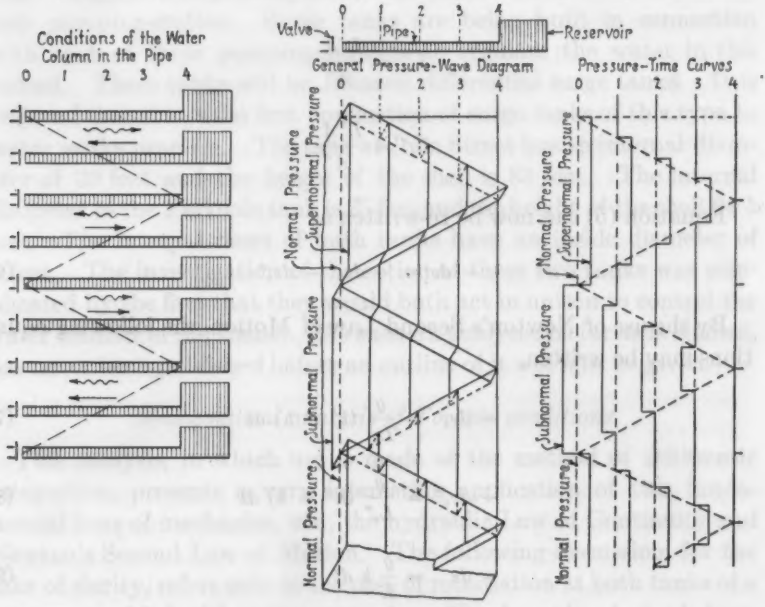

FIG. 3. WATER-HAMMER DIAGRAM

of this action is to change the *relative* flow rates in the two branches, increasing that in branch No. 2 above what would have obtained had the rise above the "balance" level in tank No. 1 not have taken place. This action will continue until the water level in the internal riser of tank No. 2 assumes such an increased height that the pressure balance is restored. A similar action would ensue if the water level in one riser tended to lag behind its balance level.

We may now insert the various values for the velocity differentials given by equations (7), (8) and (9) in equation (6) giving, after simplifying, the following relation,

$$h = \frac{\frac{h'}{L_s'} + \frac{h''}{L_s''}}{\frac{l}{L} + \frac{l}{L_s'} + \frac{l}{L_s''}} \tag{10}$$

Therefore, the various steps ordinarily taken in a surge tank calculation for each successive interval of time may be carried as far as the determination of the retarding (or accelerating) head. The value of h, the superimposed pressure at the junction, is next calculated from equation (10) and then the velocity changes from equations (7), (8) and (9).

As a practical measure in carrying out the calculation, since the velocity changes are small, the velocities themselves should be checked occasionally to make sure that the continuity relations are still true by use of the equation

$$v = v_s' + v_s'' \tag{11}$$

It may be observed that the procedure outlined is directly determinate at each step and involves no "trial and error" computations other than those ordinarily taken in surge tank analyses by the method of arithmetic integration.

A schematic plan of the two surge tanks and the tunnels is given in figure 2, and a graph of the history of the various water levels and velocities is given in figure 3.

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NOMENCLATURE

Water hammer

a = velocity of the pressure wave, feet per second;
B = the ratio of the diameter of the pipe and the thickness of shell;
g = acceleration due to gravity, feet per second per second;

K = the ratio of the elastic moduli of water and the material of the pipe shell;
L = length of the pipe from valve to reservoir in feet;
p = water hammer pressure, pounds per square inch;
t = time taken for pressure wave to travel from the valve to the reservoir and back again;
v = velocity of the water in the pipe, feet per second;
w = specific weight of water, pounds per cubic foot.

Surge tank

A = area of tunnel;
e = a subscript to denote "equivalent" length or velocity;
g = acceleration due to gravity;
h = retarding head;
L = length of tunnel;
t = time in general;
v = velocity of water in tunnel.

Note: The prime notation is used to differentiate between corresponding dimensions for the three lengths of tunnel involved.

THE WATER RESOURCES COMMISSION OF MARYLAND[1]

By Abel Wolman[2]

The biologists tell us that one of the penalties of growth is competition. This axiom is nowhere better exemplified than in the contest for water supply which has accompanied the development of every civilization. When people roamed this country in the pioneer days the assignment of water supply to various groups of individuals did not demand conscious public regulation.

In Maryland, as in other states in this country, the drought of 1930 emphasized anew the necessity for some coördination of the use of the water supply resources of the State. The rainfall deficiency of 1930 was dramatic. During that year less than 24 inches of rainfall occurred in Maryland in contrast with a normal average of from 40 to 46 inches. Newspapers seized upon this situation with the same fervor as they now discuss the deficiencies of Congress. People became sufficiently "water conscious" to be interested in discussing a water supply problem.

To those of us who have been concerned with water supply in the State of Maryland for a number of decades, the drought was merely a useful device for catching and holding the ear of important lay groups long enough to convince them of the fact that without water there is no physiological, industrial or social life.

Although the results of the drought were for the moment unfortunate, the year 1930 may always be looked upon in Maryland as a significant year, in that immediately following thereon the Water Resources Commission was created to investigate the entire problem. The Legislative Assembly of 1931 defined the duties of this Comission in the following terms:

> To review the underground and surface water resources of the State of Maryland in order to determine upon the most effective plan to preserve and allo-

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[1] Presented before the Four States Section meeting, June 8, 1932.

[2] Editor-in-Chief, Journal of the American Water Works Association. Chief Engineer, Maryland State Department of Health, Baltimore, Md.

cate such water supply resources for maximum public benefit and use; to study the problem of regulation of streams by storage reservoirs or other means; to survey the necessity for creating water service districts; to review the present practices and future necessities in the location, design and construction of dams and reservoirs; and to prepare and submit a report to the General Assembly of Maryland of 1933 embodying its findings and recommendations, including a legislative program, if such be found desirable in the light of the commission's investigations.

It may be of some interest to this group to sketch the water supply situation in Maryland and to indicate what it is hoped the Resources Commission may accomplish in placing these resources upon a permanently useful and coördinated basis for the future.

PRESENT AND PROSPECTIVE USES OF WATER

By far the greater proportion of water supply used for public purposes in Maryland is taken from surface streams. Forty-one public supplies, serving 42 independent municipalities, state institutions, camps and water districts in Maryland, as well as the District of Columbia and several smaller supplies in Pennsylvania and West Virginia, furnish the daily water consumption of approximately 1,600,000 people. Of these, 1,100,000 live in the State of Maryland and constitute approximately 67 percent of the total population. These communities draw from Maryland streams about 225,000,000 gallons in every 24 hours, of which 140,000,000 are used within the boundaries of the State.

More extended use of these surface sources will probably result in the future, so that by 1950, 1,580,000 people within and approximately 800,000 outside of the State, should require surface water supplies for public potable use. These requirements are now estimated by the Commission to approximate in 1950, 350,000,000 gallons per day.

The Commission has estimated further, through data supplied by the State Department of Health, that in 1931 the requirements for industrial and steam power uses of water constituted an additional draft on surface streams within the State which exceeded 322,000,000 gallons. Any estimate of such industrial and steam power station water supplies for 1950 is impracticable, although it is reasonable to suppose that increased industrial development along Maryland streams is probable, if stream flows are adequately regulated so as to supply sufficient quantities of water at all times.

From the above estimates the present demand on surface waters apparently exceeds 550,000,000 gallons of water per day. This total demand will probably be doubled by 1950.

ALLOCATION OF SURFACE WATER RESOURCES

One of the first concerns of the Commission is to determine what agency, if any, should be created by the State of Maryland to control the allocation of surface water resources to the best advantage of the people. The Commission has before it the task of setting up some agency which will be in a position to issue a certificate of public convenience and necessity from time to time to interested public or private groups, competitively seeking the permanent use of surface streams. Such a certificate, the Commission believes, will be desirable as a prerequisite to any future problem of water use. Something approaching a city plan, sufficiently moving in character, but stable in principle, is desirable for the adequate regulation of these valuable resources. By such a scheme of state control, the balancing of competitive demands and uses should be accomplished. At the same time unwise development, detrimental to large parts of the population, can be curbed and adjusted by some agency technically equipped and qualified to make the necessary investigations and decisions.

MEASUREMENT OF STREAM FLOW

As a necessary preliminary to a policy of allocation some careful, permanent and continuous stock-taking of stream flow is essential. The elementary bookkeeping of water resources is frequently neglected, but without it no intelligent administration of a plan is possible.

Prior to 1925 there were less than a dozen stream gaging stations in Maryland. On April 30, 1932, there were 28 of such stations operating in the State. The continuation of these and the installation of others are important undertakings for the future.

CONSOLIDATION OF WATER USERS

Duplication of water supply facilities is not peculiar to Maryland. Its financial and engineering disadvantages have been apparent for many years. Competition for available sources of supply under conditions of duplication is expensive. Consolidation of users into carefully planned water supply districts avoids duplication of supply, purification and pumping works, eliminates competition for desirable

sources and makes it possible to maintain competent engineering forces for the control of the supply. Many communities, too small individually to provide their own water systems, may secure safe and ample public service by such joint action.

Such regional control of the distribution of water may be suggested by the Commission in the form of permissive State legislation, in order to facilitate more prompt accomplishment of this desirable purpose than has been the case in the past, where the creation of each water supply district required a great many years of propagandizing and of education.

STREAM REGIMENTATION

The occurrence of floods with their damaging effects has also given rise to careful consideration of the regulation of stream flow. The wide variations in flow characteristic of Maryland streams make the usefulness of these streams without regimentation very limited. The major streams in the State of Maryland show maximum flows ranging from 20 to 80 times their average flow. As a consequence, destructive floods and damaging droughts follow each other in cycles. The most adequate development of these resources calls for procedures of storage and release which would result in the elimination of flood hazards, in the increase of low flows of the stream and in the stabilizing of the safe yields for our major sources of supply.

CONTROL OF STRUCTURES ON SURFACE STREAMS

With the exception of the control which the State Department of Health exercises over the location and the design of water supply dams for public water supply systems, no agency in the State is at present equipped by law or by personnel to pass upon the design, construction or maintenance of dams for public water supplies or hydroelectric developments.

If a dam is constructed in a state adjacent to Maryland on a stream flowing into Maryland, all of the elements of the development of that project are scrutinized by some state agency, even though the collapse of such a dam would create damage in the State of Maryland. If the same dam were built in Maryland on the same stream, the amount of supervision over its design and construction would be practically nil.

With the history of failures of dams before the Commission, this is another water supply problem to which it intends to give its attention.

SUMMARY

The Water Resources Commission, therefore, finds itself confronted in the State of Maryland with a practically uncontrolled situation in the development of water resources. Elements of quality and safety of supply are, of course, controlled by the State Department of Health. A more elaborate and intelligent policy of State regulation to preserve and allocate these resources for best use, to measure their flow, to provide district grouping for their most convenient and economical development and to arrange for some form of check upon the structures which are placed upon such streams, is the aim of the Commission. In the accomplishment of this task the practice of other states in this country and abroad is being reviewed. Their application to the local conditions in Maryland is being considered. When these have been crystallized, it is the hope of the Commission that they may be formulated into law.

The Commission, appointed by Governor Albert C. Ritchie, consists of the following individuals:

MR. F. H. DRYDEN, City Engineer, Salisbury.
DR. THOMAS W. KOON, formerly Mayor of Cumberland, Cumberland.
DR. E. B. MATHEWS, State Geologist, Maryland Geological Survey, Baltimore.
MR. RICHARD MOMMERS, Superintendent, American Sugar Refining Company, Baltimore.
MR. ROBERT B. MORSE, Chief Engineer, Washington Suburban Sanitary District, Hyattsville.
MR. PHILIP B. PERLMAN, Attorney-at-Law, Baltimore.
MR. ABEL WOLMAN, Chief Engineer, Maryland State Department of Health, Baltimore, *Chairman*.

OBSERVATIONS ON UTILITY FINANCES AND ACCOUNTING[1]

By John W. Cunningham[2]

Just as waterworks men gain from the study of operating practice in other communities, those interested in management can benefit from the comparison of financial plans and costs. Prerequisite to such study are clear, illuminating and substantially uniform reports giving capital set-ups and annual operating costs. For privately owned plants, most states have adopted the Uniform Classification of Accounts for Water Utilities, prepared by the National Association of Railway and Utilities Commissions. The reports, made to the various state regulatory bodies, are complete and uniform, although companies have methods of juggling items which sometimes distort the true picture. As regards municipal plants, the State of Washington is the only one in the Northwest where any degree of standardization is found. The Washington law and its Division of Municipal Corporations should be adopted by other states. By frequent checking up and supervision of local accounts, excellent control is assured, although, of course, this department cannot dictate to local governments in matters of management. As to the smaller water utilities outside of Washington there is little to be said. With few exceptions, they have no records worth mentioning, and do not know where to start for proper accounting. As a matter of fact no water plant, regardless of size, should be without book records which show clearly its financial status as a department of the general city government.

The fundamental information of utility report is contained in two statements; first, the assets and liabilities, giving the capital set up, and second, the revenue and expense statement, usually on an annual basis. Where these records do exist, they should be made readily available in printed form for those interested. It would be immensely valuable if the Washington Division of Municipal Corpora-

[1] Presented before the Pacific Northwest Section meeting, May 13, 1932.

[2] Baar and Cunningham, Consulting Engineers, Portland, Ore.

tions and corresponding departments in every state could compile, correlate and publish in condensed form public utility financial statements. If these statements were set up not only for the current year, but also in tabular or chart form for a period of years, even for the life of the plant, a true perspective of the financial development of the property would be provided.

BOOK RECORDS SHOULD FIT THE FACTS

Fundamentally, an asset and liability statement shows on one side the value of property owned and on the other the debts, the difference being net worth or surplus. It might be expressed as an algebraic equation:

(A) Value − Debt = Surplus, or,
(B) Value = Debt + Surplus

For a public utility the most important index of value is the cost of reproducing the plant today, or the original cost of the plant, with allowance for depreciation accrued. Depreciation is defined as the reduction of value with age and use. Because original cost is a fixed item and depreciation is continually changing they are carried separately, as follows:

(C) Value = Cost − Depreciation

For a municipal plant set up, more especially considered in this discussion, the debt is mainly in the form of bonds, and for the retirement of these bonds a sinking fund is accumulated. The minor items of current liabilities are here disregarded along with current assets. The net debt is then:

(D) Debt(net) = Bonds Outstanding − Sinking Fund

Substituting Equations (C) and (D) in (B) and rearranging we get:

(E) Cost + Sinking Fund = Bonds + Depreciation (Reserve) + Surplus

This is the boiled down substance of an asset and liability statement. The amount of outstanding bonds and the sinking fund accumulation are always readily and correctly ascertained. The other three items, while essential to a correct financial picture of the project, are more often wrong than right. The reason is that almost every utility, public or private, has passed through periods of poor management

and poorly considered even though honest bookkeeping. Many plants date back to a time when there were no records of cost or the records were lost by fire or otherwise. The book records often start from a point where the plant was purchased from a former owner. The purchase price may have been exorbitant, due to a bad bargain. In many utilities there are plant units long since in fact abandoned, but still carried on the books as part of the operating plant. The allowances for depreciation in the past and even today commonly have no rhyme or reason, they are simply somebody's very poor guess. All of these factors make the utility's book records of cost and depreciation anything but what they should be; and seldom an accurate measure of the plant value.

In order that the book statement may mean something, and present a true picture, there should be an occasional reappraisal of the entire physical property. This would merely follow the example of the merchant, who is not satisfied with his book record of purchases and sales, but takes a periodical inventory of stock on hand. The merchant makes his inventory each year. For a complete waterworks plant, reappraisal at yearly or any other regular intervals would be needless and out of the question. The requirements of each case would have be to separately considered, and appraisals made only to fill a definite need. As one feature, a thorough and detailed plant inventory, once made, would have permanent value. Subsequent check ups for non-operating property, depreciation corrections and other adjustments could be readily made without complete reappraisal.

The valuation of a utility would and should be followed by correction of the book accounts. The cost and depreciation accounts being adjusted to their right amounts would necessitate "taking up the slack" elsewhere. In the municipal utility this would ordinarily be in the figure for surplus.

THE HANDLING OF DEPRECIATION

The preceding topic dealt with capital accounts, and considered depreciation in the aggregate, or total accrued depreciation. In book accounting, this figure is built up and added to by an annual allowance which is supposed to represent the loss in value for the current year. Here we find a great variation in practice, and few cities where the rate is calculated on any rational basis. Without here entering into any discussion of sinking fund versus straight line

methods, at least it may be said that for any plant there should be an analysis of the actual depreciation factors and a logical determination of a composite figure to be used.

The total depreciation, or depreciation reserve, is often referred to as the "depreciation fund." In municipal utilities this is confused with actual cash funds, as something to be appropriated and spent. We often hear the assertion that some improvement or replacement is made "out of the depreciation fund." In a sense this is true, and depreciation charges may wind up as replacements. The mechanics of the disposition of depreciation are entirely different, and a direct spending of the depreciation fund or reserve is incorrect. Actually the depreciation reserve is reduced only when some item of plant is replaced and written off the books. In such case the total book cost is reduced by the cost of this one item and the total depreciation is reduced by the amount previously charged against it. The new item, even when it replaces the old one, is then treated exactly as any other unit of capital investment.

The "depreciation fund" idea also leads some utility executives to believe that by holding down on depreciation charges they are practicing economy. They think that since depreciation is an operating expense, they are cutting expenses. In point of fact so doing does not make a nickel of difference in the cash money available. The only effect is to give a false figure for annual net income, and to build up false capital accounts for depreciation and surplus, which serve no good purpose.

DEPRECIATION AND AMORTIZATION

In considering utility financial set ups, an error which comes up again and again is the idea that revenues must provide for depreciation, and at the same time amortize the debt, or in other words depreciation and amortization must be considered as part of the costs. The fallacy is so evident, yet so difficult to explain that it will be considered from several angles.

Depreciation is heretofore defined as the reduction in value with age or use. Amortization is the extinguishment of a liability or debt, usually on some regular installment plan. The increments to depreciation are accepted as one of the operating expenses of a utility, although not an actual cash operating expense, like power, labor, and supplies. Annual depreciation is simply a book credit, or addition to a capital reserve account. In contrast with this, amorti-

zation requirements while not an operating expense, are a vital cash necessity and outlay. Money for amortization is taken as cash from an appropriate capital reserve account and used to extinguish a capital liability. To put it briefly, although not perhaps with technical accuracy, depreciation is taken from revenues and added to a capital account, while the amortization installment is withdrawn from a capital account. Depreciation and amortization are both to be considered and provided for, of course, but not in the same set up. Using one simile, they are to be considered in series, but not in parallel.

Assume that a man purchases an automobile for $1000 paying cash, and the automobile has a life of four years. He charges with other operating expenses $250 per year as depreciation, setting it aside in a reserve. At the end of four years his car is worthless, but he has a fund of $1000 for the purchase of a new one. The process could be repeated indefinitely.

In another case assume that a man borrows money to buy a similar automobile, and contracts to pay or amortize his $1000 debt at the rate of $250 per year. After four years he has no car, and also is out of debt, and in a position to repeat the process.

If in this last case the owner paid his debt and also set up a depreciation reserve, he would have to earn $500 per year, and after four years would both be out of debt and have money for a new car. He would have eaten his cake and still have it. Each time he repeated the process he would add one more car to his fleet. This would be a good way to build up an estate, but not a sound method for utility financing.

Actually the only relationship of depreciation to amortization is that both come in annual installments and are somewhat similar in magnitude. In public work financed from bond issues, it is a recognized principal that the bonds should be paid off in the life of the improvement. A pavement good for twenty years should not be financed by thirty year bonds. This is the same as saying that the actual annual depreciation should not exceed the annual amortization, a rule which should always be observed. Therefore, if a utility set-up, covering the future earnings and expenses provides fully for amortization of debt within the reasonable life of the property, no depreciation need be added. To do so would be a duplication and an unnecessary burden on earning capacity.

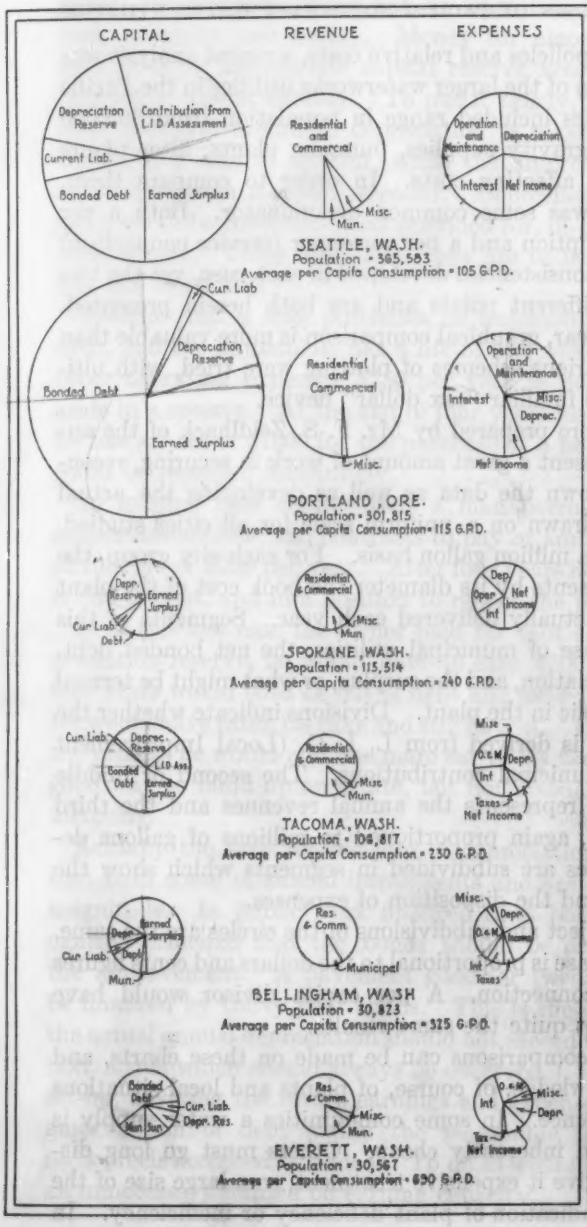
A FINANCIAL COMPARISON OF PACIFIC NORTHWEST WATER UTILITIES

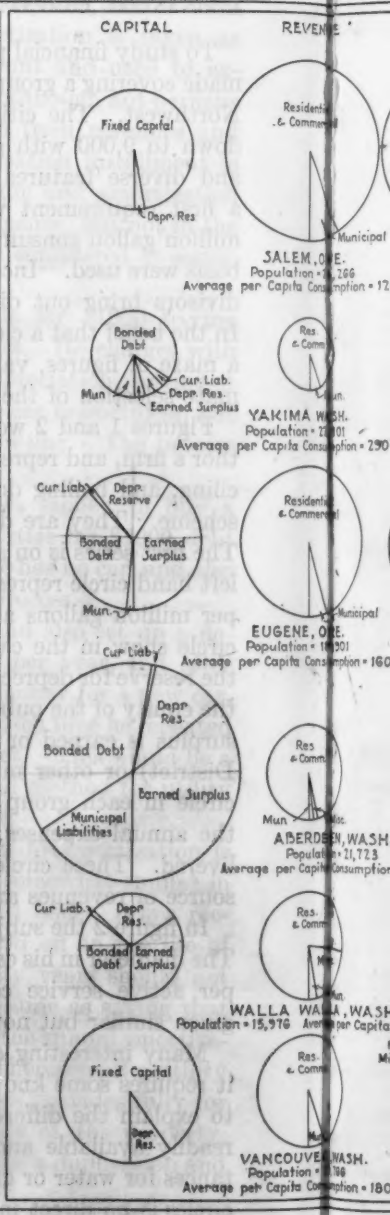
To study financial policies and relative costs, a recent analysis was made covering a group of the larger waterworks utilities in the Pacific Northwest. The cities included range in population from 365,000 down to 9,000 with gravity supplies, pumping plants, filter plants and diverse features affecting costs. In order to compare them, a first requirement was some common denominator. Both a per million gallon consumption and a per consumer (service connection) basis were used. Inconsistencies developed in each case, yet the two divisors bring out different points and are both herein presented. In the belief that a clear, graphical comparison is more valuable than a maze of figures, various schemes of plotting were tried, with ultimate selection of the familiar "tax dollar" device.

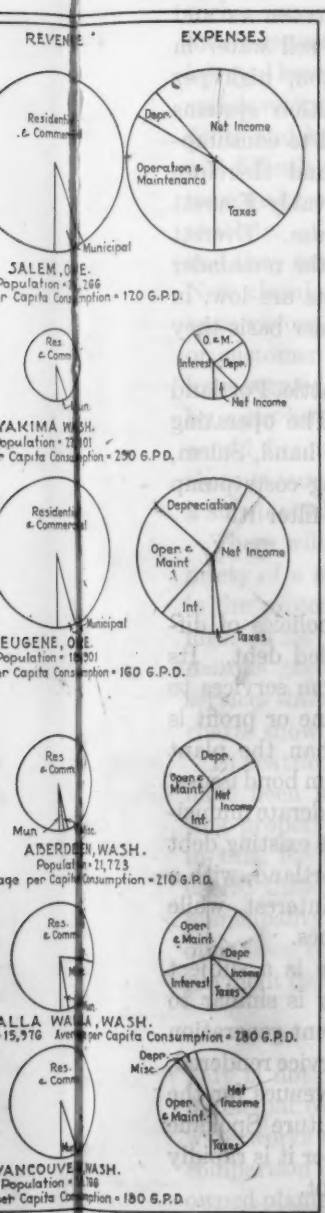
Figures 1 and 2 were prepared by Mr. F. S. Zeidlhack of the author's firm, and represent a great amount of work in securing, reconciling, and boiling down the data as well as developing the actual scheme. They are drawn on a uniform scale for all cities studied. The first series is on a million gallon basis. For each city group, the left hand circle represents by its diameter the book cost of the plant per million gallons actually delivered each year. Segments of this circle show in the case of municipal utilities, the net bonded debt, the reserve for depreciation, and the surplus, or what might be termed the equity of the public in the plant. Divisions indicate whether the surplus is earned or is derived from L. I. D. (Local Improvement District) or other municipal contributions. The second or middle circle in each group represents the annual revenues and the third the annual expenses, again proportioned to millions of gallons delivered. These circles are subdivided in segments which show the source of revenues and the disposition of expenses.

In figure 2 the subject and subdivisions of the circles are the same. The diameter in his case is proportional to the dollars and cents figures per active service connection. A per capita divisor would have given similar but not quite the same results.

Many interesting comparisons can be made on these charts, and it requires some knowledge, of course, of plants and local situations to explain the difference. In some communities a water supply is readily available and inherently cheap. Others must go long distances for water or give it expensive treatment, so a large size of the circles is no direct indication of plant deficiency or inefficiency. In


CAPITAL
REVENUE
EXPENSES
Depreciation Reserve
Contribution from L.I.D Assessment
Current Liab.
Bonded Debt
Earned Surplus
Residential and Commercial
Misc.
Mun.
Operation and Maintenance
Depreciation
Interest
Net Income
SEATTLE, WASH.
Population = 365,583
Average per Capita Consumption = 105 G.P.D.
Cur. Liab
Depreciation Reserve
Bonded Debt
Earned Surplus
Residential and Commercial
Misc.
Operation and Maintenance
Interest
Misc.
Deprec.
Net Income
PORTLAND, ORE.
Population = 301,815
Average per Capita Consumption = 115 G.P.D.
Depr. Reserve
Earned Surplus
Cur Liab
Debt
Residential & Commercial
Misc
Mun
Dep.
Oper
Net Income
Int
SPOKANE, WASH.
Population = 115,514
Average per Capita Consumption = 240 G.P.D.
Cur Liab
Deprec. Reserve
L.I.D Ass.
Bonded Debt
Earned Surplus
Residential & Commercial
Misc
Mun.
Misc
O. & M.
Depr
Int
Taxes
Net Income
TACOMA, WASH.
Population = 106,817
Average per Capita Consumption = 230 G.P.D.
Earned Surplus
Depr
Depr
Cur Liab
Debt
Mun.
Res. & Comm.
Municipal
Misc.
Depr
O. & M.
Income
Int
Taxes
BELLINGHAM, WASH
Population = 30,823
Average per Capita Consumption = 325 G.P.D.
Bonded Debt
Cur Liab.
Depr. Res.
Earned Surplus
Res. & Comm.
Misc.
Mun.
Misc.
Depr
O. & M.
Int
Misc.
Depr
Tax
Net Income
EVERETT, WASH.
Population = 30,567
Average per Capita Consumption = 630 G.P.D.


CAPITAL
REVENUE
Fixed Capital
Depr. Res
Residential & Commercial
Municipal
SALEM, ORE.
Population = 24,266
Average per Capita Consumption = 12
Bonded Debt
Cur Liab.
Depr. Res.
Earned Surplus
Mun
Res. & Comm
Mun.
YAKIMA WASH.
Population = 22,101
Average per Capita Consumption = 290
Cur Liab
Depr Reserve
Bonded Debt
Earned Surplus
Mun.
Residential & Commercial
Municipal
EUGENE, ORE.
Population = 16,901
Average per Capita Consumption = 160
Cur Liab
Depr Res.
Bonded Debt
Earned Surplus
Municipal Liabilities
Res. & Comm.
Mun
Misc.
ABERDEEN, WASH
Population = 21,723
Average per Capita Consumption
Cur Liab
Depr Res.
Bonded Debt
Earned Surplus
Res. & Comm
Mun
WALLA WALLA, WASH
Population = 15,976
Average per Capita
Fixed Capital
Depr Res.
Res. & Comm
VANCOUVER, WASH.
Population = 9,786
Average per Capita Consumption = 180



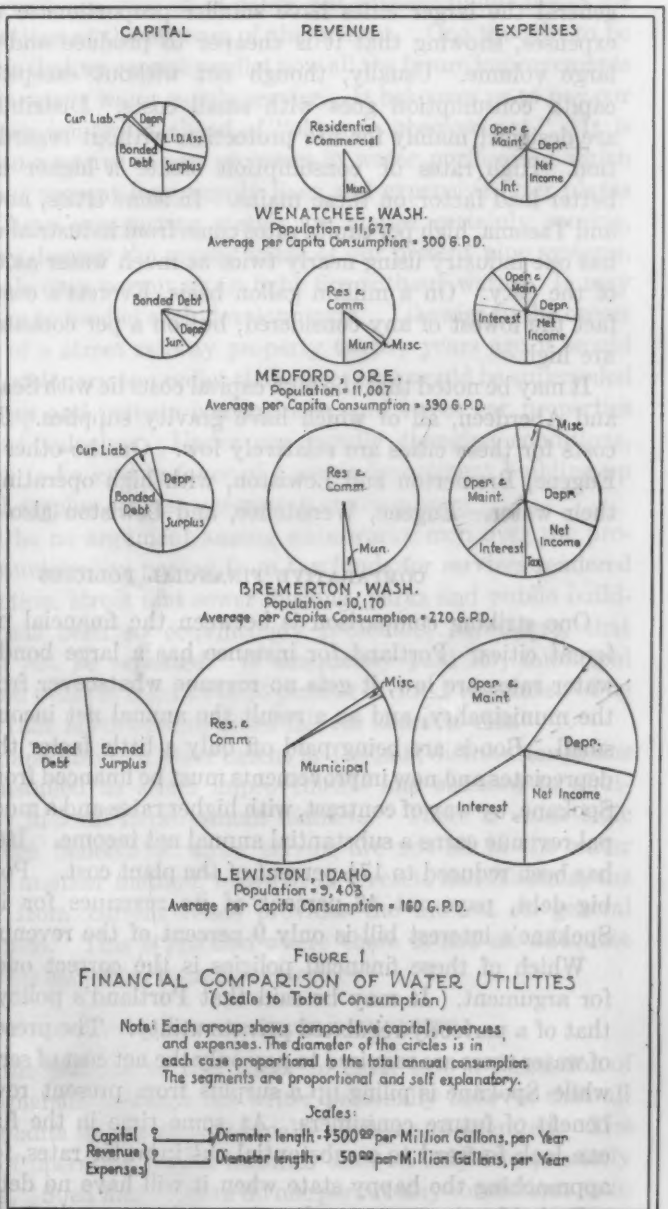


FIGURE 1

FINANCIAL COMPARISON OF WATER UTILITIES

(Scale to Total Consumption)

Note: Each group shows comparative capital, revenues and expenses. The diameter of the circles is in each case proportional to the total annual consumption. The segments are proportional and self explanatory.

Scales:

Capital } ——— Diameter length = $500.00 per Million Gallons, per Year
Revenue } ——— Diameter length = 50.00 per Million Gallons, per Year
Expenses }

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general the larger cities have smaller proportionate revenues and expenses, showing that it is cheaper to produce and sell water in large volume. Usually, though not without exception, high per capita consumption goes with small costs. Distribution systems are designed mainly for fire protection without regard to consumption. High rates of consumption create a higher and therefore better load factor on these mains. In some cities, notably Everett and Tacoma, high per capita rates come from industrial use. Everett has one industry using nearly twice as much water as the remainder of the City. On a million gallon basis, Everett's costs are low, in fact the lowest of any considered, but on a per consumer basis they are high.

It may be noted that the high capital costs lie with Seattle, Portland and Aberdeen, all of which have gravity supplies. The operating costs for these cities are relatively low. On the other hand, Salem, Eugene, Bremerton and Lewiston, with high operating costs pump their water. Eugene, Wenatchee, and Lewiston also filter it.

COMPARATIVE FINANCIAL POLICIES

One striking comparison is between the financial policies of different cities. Portland for instance has a large bonded debt. Its water rates are low, it gets no revenue whatsoever from services to the municipality, and as a result the annual net income or profit is small. Bonds are being paid off only a little faster than the plant depreciates and new improvements must be financed from bond issues. Spokane, by way of contrast, with higher rates and a moderate municipal revenue earns a substantial annual net income. Its existing debt has been reduced to 17½ percent of the plant cost. Portland, with a big debt, pays out 48 percent of its revenues for interest, while Spokane's interest bill is only 9 percent of the revenues.

Which of these financial policies is the correct one is a subject for argument. It may be said that Portland's policy is similar to that of a perfectly regulated private utility. The present generation of water users are required to pay only the net cost of service rendered, while Spokane is piling up a surplus from present revenues for the benefit of future consumers. At some time in the future Spokane can look forward to a substantial cut in water rates, for it is rapidly approaching the happy state when it will have no debt.

Probably the correct policy is one between these two extremes,

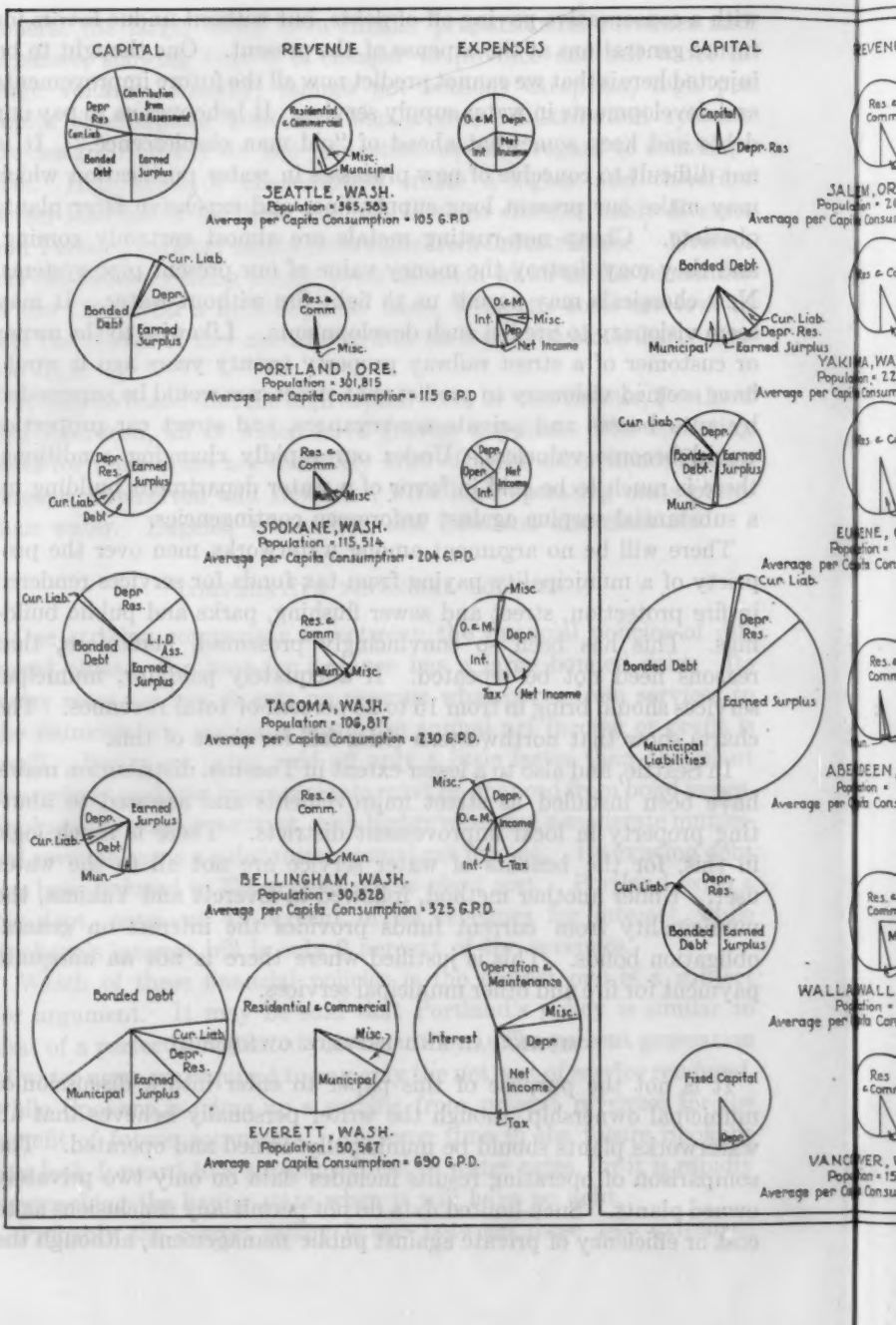
with a conservative paying off of debts, but without undue favors for future generations at the expense of the present. One thought to be injected here is that we cannot predict now all the future improvements and developments in water supply service. It behooves us to pay our debts and keep somewhat ahead of "old man obsolescence." It is not difficult to conceive of new processes in water purification which may make our present long supply lines and expensive filter plants obsolete. Cheap non-rusting metals are almost certainly coming, and they may destroy the money value of our present pipe systems. New chemicals may permit us to fight fire without water. It may seem visionary to predict such developments. Likewise to the owner or customer of a street railway property twenty years ago it would have seemed visionary to predict that street cars would be superseded by auto busses and private conveyances, and street car properties would become valueless. Under our rapidly changing conditions, there is much to be said in favor of a water department building up a substantial surplus against unforeseen contingencies.

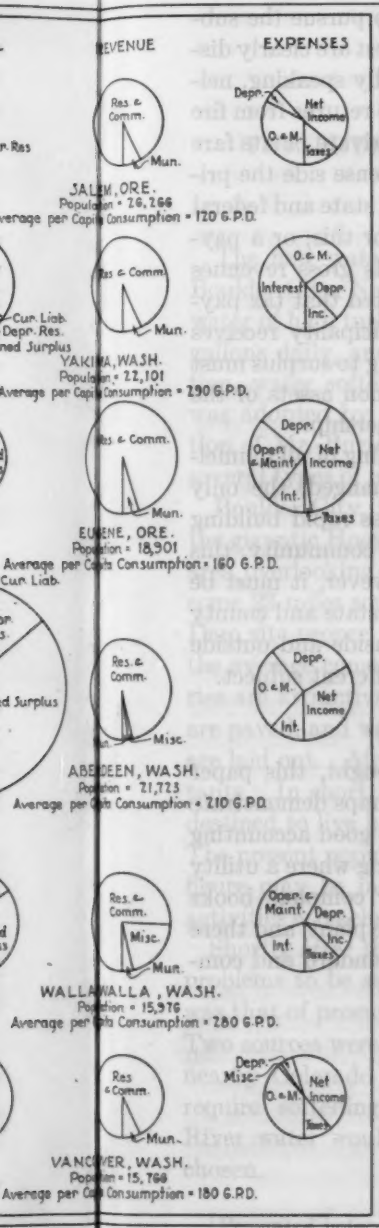
There will be no argument among waterworks men over the propriety of a municipality paying from tax funds for services rendered in fire protection, street and sewer flushing, parks and public buildings. This has been so convincingly presented, heretofore, that reasons need not be repeated. If adequately paid for, municipal services should bring in from 15 to 25 percent of total revenues. The charts show that northwestern cities fall far short of this.

In Seattle, and also to a lesser extent in Tacoma, distribution mains have been installed as street improvements and assessed to abutting property in local improvement districts. There is much logic in this, for the benefits of water service are not all to the water user. Under another method, followed in Everett and Yakima, the municipality from current funds provides the interest on general obligation bonds. This is justified where there is not an adequate payment for fire and other municipal services.

MUNICIPAL AND PRIVATE OWNERSHIP

It is not the purpose of this paper to enter into a discussion of municipal ownership, though the writer personally believes that all waterworks plants should be municipally owned and operated. The comparison of operating results includes data on only two privately owned plants. Such limited data do not permit any conclusions as to cost or efficiency of private against public management, although the


CAPITAL
REVENUE
EXPENSES
Depr Res
Contribution from L.I.D. Assessment
Cur Liab
Bonded Debt
Earned Surplus
Residential & Commercial
Misc.
Municipal
O. & M.
Depr
Int
Net Income
SEATTLE, WASH.
Population = 365,583
Average per Capita Consumption = 105 G.P.D.
Cur. Liab.
Depr.
Bonded Debt
Earned Surplus
Res. & Comm
Misc.
PORTLAND, ORE.
Population = 301,815
Average per Capita Consumption = 115 G.P.D.
Depr Res.
Earned Surplus
Cur Liab
Debt
Res. & Comm.
Mun
Misc.
Depr
Oper.
Int.
Net Income
SPOKANE, WASH.
Population = 115,514
Average per Capita Consumption = 204 G.P.D.
Cur Liab
Depr Ras.
Bonded Debt
L.I.D Ass.
Earned Surplus
Res. & Comm
Mun
Misc.
O. & M.
Depr
Int.
Tax
Net Income
TACOMA, WASH.
Population = 106,817
Average per Capita Consumption = 230 G.P.D.
Depr.
Earned Surplus
Cur Liab.
Debt
Mun
Res. & Comm.
Misc.
Depr.
O. & M.
Income
Inf.
Tax
BELLINGHAM, WASH.
Population = 30,828
Average per Capita Consumption = 325 G.P.D.
Bonded Debt
Cur. Liab.
Depr. Res.
Municipal
Earned Surplus
Residential & Commercial
Misc.
Municipal
Operation & Maintenance
Misc.
Interest
Depr
Net Income
Tax
EVERETT, WASH.
Population = 30,567
Average per Capita Consumption = 690 G.P.D.
CAPITAL
Capital
Depr. Res
Bonded Debt
Cur. Liab.
Depr. Res.
Municipal
Earned Surplus
Cur. Liab.
Depr.
Bonded Debt
Earned Surplus
Mun.
Average per Capita Consumption
Cur. Liab.
Depr. Res.
Bonded Debt
Earned Surplus
Municipal Liabilities
Cur. Liab.
Depr. Res.
Bonded Debt
Earned Surplus
Fixed Capital
Depr.



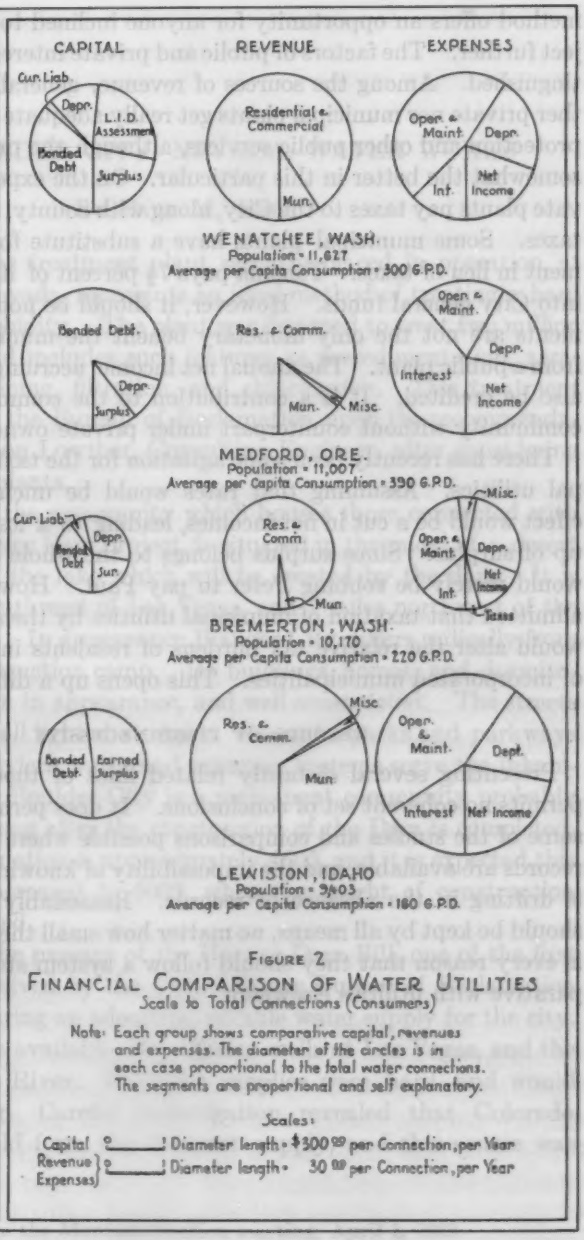


FIGURE 2.

FINANCIAL COMPARISON OF WATER UTILITIES

Scale to Total Connections (Consumers)

Note: Each group shows comparative capital, revenues and expenses. The diameter of the circles is in each case proportional to the total water connections. The segments are proportional and self explanatory.

Scales:

Capital } ○——! Diameter length = $300.00 per Connection, per Year
Revenue } ○——! Diameter length = 30.00 per Connection, per Year
Expenses }

method offers an opportunity for anyone inclined to pursue the subject further. The factors of public and private interest are clearly distinguished. Among the sources of revenue, generally speaking, neither private nor municipal plants get really adequate returns from fire protection and other public services, although the private plants fare somewhat the better in this particular. On the expense side the private plants pay taxes to the City, along with county, state and federal taxes. Some municipal plants have a substitute for this, or a payment in lieu of taxes. Tacoma pays 7½ percent of its gross revenues into City general funds. However, it should be noted that tax payments are not the only monetary benefit the municipality receives from a public plant. The annual net income, accruing to surplus must also be credited. It is a contribution to the common assets of the community without counterpart under private ownership.

There has recently been some agitation for the taxing of all municipal utilities. Assuming that rates would be unchanged, the only effect would be a cut in net incomes, leading to a less rapid building up of surplus. Since surplus belongs to the whole community, this would merely be robbing Peter to pay Paul. However, it must be admitted that taxation of municipal utilities by the state and county would alter the relative tax burdens of residents inside and outside of incorporated municipalities. This opens up a different subject.

RECORDS OF FIRST NECESSITY

Presenting several distantly related lines of thought, this paper permits no coherent set of conclusions. It does perhaps demonstrate some of the studies and comparisons possible where good accounting records are available, and the impossibility of knowing where a utility is drifting in the absence of records. Reasonably complete books should be kept by all means, no matter how small the plant, and there is every reason that they should follow a system standard and comparative with utilities elsewhere.

THE BOULDER CITY, NEVADA, WATER WORKS[1]

By Earl M. Kelly[2]

The new water treatment plant recently placed in operation at Boulder City, Nevada, represents an ideal method of treating a hard water of high turbidity. The plant was designed to treat two million gallons daily, and includes such features as presedimentation, aeration, water softening, filtration, and chlorination. This treatment was adopted by the Bureau of Reclamation upon the recommendation of Mr. Burton Lowther, Consulting Engineer, after considering several types of plants.

Boulder City, the community which houses those connected with the gigantic Hoover Dam project, is situated in the midst of a desert area overlooking the lake which will be created by the dam. It is some 23 miles southwest of Las Vegas, and 7 miles northwest of the Dam site proper. In appearance Boulder City differs radically from the average construction camp. Its buildings, homes, and dormitories are attractive in appearance, and well constructed. The streets are paved, and well lighted at night. Beautiful parks and parkways are laid out. Modern water and sewerage systems serve the inhabitants. In short, Boulder City is a permanent community probably destined to live long after the construction of the Dam is completed. The present population is approximately 4500, and it is expected this figure may be increased to 6000, when the height of construction activities is reached.

Shortly after the passage of the Hoover Dam Bill, one of the first problems to be solved by the United States Bureau of Reclamation was that of procuring an adequate, potable water supply for the city. Two sources were available, the artesian wells at Las Vegas, and the nearby Colorado River. Both the supplies were hard, and would require softening. Careful investigation revealed that Colorado River water would form the cheapest supply, and this source was chosen.

[1]Presented before the Montana Section meeting, April 1, 1932.

[2]Engineer, The Dorr Company, Inc., Los Angeles, Calif.

The Boulder City water works system is divided into two distinct parts: the pretreatment works situated on the banks of the river a mile below the Dam site, and the softening plant at Boulder City.

PRETREATMENT WORKS

The pretreatment works consist of the river intake, the presedimentation clarifier, sludge pump, the 30,000 gallon sump tank, and the high head pumps which deliver the water to the softening plant at Boulder City.

The river intake consists essentially of three centrifugal pumps mounted on a pump car so arranged that they can be moved up or down on an incline, to suit varying water levels in the river. Each pump has a capacity of 560 g.p.m., and each pump has a 5-inch galvanized steel individual suction pipe. The end of each pipe is approximately 12 feet below the pump inlet, the purpose being to have it at an elevation which would bring it close to the water surface, thereby drawing from the least turbid zone. A strainer is placed at the inlet of each pipe to prevent the entrance of large particles which might damage the pump impeller.

The pump car is constructed of fabricated structural steel, and the plan, or floor on which the pump rests is 7 feet 5 inches long by 14 feet wide. From side elevation the car is a right triangle in shape, with the hypotenuse paralleling the incline. It is supported by four traction wheels which operate on two 45 pound steel rails spaced on 7 feet centers. The rails are attached to a concrete base, which makes an angle of 47°30′ with the horizontal. A motor-driven hoist is used to raise and lower the pump car to suit the elevation of the river.

Provision is made to draw water from seven intermediate points, equally spaced between the low water elevation 643.0 and the high water elevation 683.0. At any of the draw-off points the pumps discharge through a common flexible rubber connection into a single 10-inch standard cast iron pipe. This pipe is laid in a rock gutter, following the centerline of the rails, and extends from the bottom elevation of 650.6 upward to the presedimentation clarifier, approximately 100 feet distant. Just ahead of the clarifier the flow is divided into four parts, and is introduced into the influent channel through 8-inch pipe inlets.

The presedimentation clarifier equipped with a Dorr mechanism is 55 feet square by 11 feet side water depth, and is of sufficient size to

allow a 2.5 hours detention period, at design flow. The bottom slopes one inch to 12 inches, to a center discharge cone. The site for the clarifier was excavated in a solid rock ledge overhanging the river. The water surface elevation in the clarifier is 742.5, or 96.5 feet above average water elevation in the river.

Across-the-tank flow is the principle used and especial care was given to the design of the influent arrangement to insure absolute uniformity of distribution, and a minimum entrance velocity, thereby creating ideal settling conditions.

The great amount of suspended matter contained in Colorado River water made necessary the use of presedimentation ahead of chemical treatment. Analyses made in the general vicinity of Boulder Canyon indicated a suspended solids content of as low as 395, reaching a maximum of 59,400 p.p.m. The mean suspended solids content was slightly over 6000 p.p.m.

Original studies made on the water indicated that the softening plant could economically handle a water which contained a suspended solids content not to exceed 250 p.p.m. under average conditions, and it was on that basis the area and detention period were provided. Actual tests, with all three river pumps operating and delivering a water containing 8240 p.p.m., showed the overflow contained but 190 p.p.m., representing a total removal of 97.8 percent in the clarifier.

Under average conditions approximately 50 tons of dry solids per day will be deposited in the clarifier, and during flood periods this figure will be between two hundred and three hundred tons daily; therefore, it was deemed economical and most desirable to provide for continuous sludge removal, and a Dorr traction Clarifier mechanism was installed.

The solids, or sludge, swept to the clarifier central cone are discharged to the river by means of a 4-inch duplex Dorrco diaphragm sludge pump. The capacity of the pump may be varied, and is ordinarily set to withdraw the solids at the rate of deposition by the clarifier rakes. This method of operation results in a thick sludge of uniform density, with a low water loss. Tests on sludge, made at the same time the influent and effluent tests were conducted, indicated a solid content of 30 percent by weight. The net water loss was approximately 1.8 per cent of the total flow. Provisions are made for the recirculation of a portion of the sludge to the clarifier influent, which is used to build up solid concentrations in the feed when the initial suspended solids are low. This has a tendency to increase the settling rate. A gravity drain for the clarifier is also provided.

The clarifier effluent flows by gravity to an adjacent 30,000 gallon sump tank, which feeds the three high head centrifugal pumps at Pumping Plant No. 1. These pumps have a capacity of 450 g.p.m. each and force the water through 19,904 feet of steel pipe line to Pumping Plant No. 2, at an elevation of 986 feet above Pumping Plant No. 1. The equipment in Plant No. 2 is similar to that in No. 1 Plant. To take care of inequalities of pumping, a 90 feet high surge tank has been built just ahead of No. 2 Plant.

The No. 2 Plant discharges the water through an additional 14,578 feet of steel pipe to the aerator on top of the 100,000 gallon equalizing tank, at Boulder City, which is 850 feet above No. 2 Pumping Plant.

The aerator, which is of the Aer-O-Mix design, is provided to effect a reduction in the amount of free CO_2 contained in the water, and to oxidize any minute vegetable organisms subsequent to the softening operation. Following aeration the water drops into the equalizing tank and from there flows by gravity to the nearby softening plant.

SOFTENING PLANT

The Boulder City water softening plant is designed to soften the Colorado River water by a modified form of excess lime-soda ash treatment. The latest innovations in water softening practice, such as are found only in plants built during the past two years, are incorporated in this layout.

Aerated water from the equalizing tank first enters the plant at the inlet to No. 1 Agitator, at which point a known amount of lime and soda ash, together with a certain excess, is applied to the water, and the mixture is agitated violently for 15 minutes. The thoroughly mixed water is then gently agitated in No. 2 Agitator for another 15 minutes, and in this agitator the reaction occurs. The water leaving No. 2 Agitator is in a well-flocculated condition, ideal for rapid sedimentation.

Agitators numbers 1 and 2 are of the same size—14 feet square by 12 feet water depth. Each is equipped with a Dorr impeller agitator mechanism, composed of a motor and speed reducer which drives an 8 feet diameter impeller. The impeller operates in a draft tube and is designed so as to create a vertical overturning of the contents of the tank. The driving mechanism is provided with variable speed features and the speed of the impeller can be changed at will. By this means the optimum vertical velocity for the ever changing water may be found. Particular attention was given to the design of the agitation units, as experiments on this water have shown that thor-

ough mixing, followed by flocculation, makes possible shorter detention periods in the clarifier than would otherwise be possible.

From Agitator No. 2 the water flows into No. 1 clarifier, which is 45 feet square by 10 feet water depth. A removal of the bulk of the precipitate formed by the chemical reactions is here accomplished during the two hour settling period allowed, by a Dorr traction clarifier mechanism which continuously removes the precipitated solids. Sludge from the clarifier center cone is removed by either of two 4-inch Simplex Dorrco pressure pumps installed for that purpose. It can be wasted, all or in part, to a sludge lagoon, or to the sewer; or it can be recirculated through the system.

As mentioned above, excess chemicals are added with the normal dosage. This procedure is necessary to insure maximum precipitation of certain undesirable calcium and magnesium compounds. Additional analyses showed that because of this excess the effluent from clarifier No. 1 became slightly caustic.

To overcome this, the water is given a carbonation period of approximately thirty minutes, in a basin 54 feet long by 5½ feet wide by 12 feet water depth. The CO_2 gas, supplied by an International Filter Company coke-burning plant installed in the basement of the filter building, is distributed throughout the basin by means of a perforated brass-pipe grid system in the bottom of the channels. Only enough CO_2 gas is added to combine with the causticity. This treatment results in the formation of minute particles of normal carbonate, which although suspended, exhibit an exceedingly slow settling rate, and if settled without further treatment would require an almost prohibitive detention period.

To the partly carbonated water, inert sludge from No. 2 clarifier is added; the mixture is agitated, and flocculated for a 30 minute period in Agitators numbers 3 and 4 which are identical to the first set of agitators. In these two units the fine precipitate formed from first carbonation exhibits a tendency to adhere to the return sludge and flocculation in the form of large, fast settling particles takes place.

The flocculated water is next introduced into clarifier No. 2, of the same size as No. 1, and also equipped with a Dorr traction clarifier mechanism for continuous removal of the precipitate. Sludge is allowed to accumulate in this clarifier until a thick blanket is formed. After this, a thick sludge of known solids concentration is re-circulated to a point just ahead of the second set of agitators. The excess sludge is either wasted or returned to the first agitators.

The resulting overflow is given a second period of carbonation in a basin similar to the first, to convert any remaining normal carbonates into soluble bi-carbonates, and it is then filtered through the rapid sand filters.

The softening end of the plant is very flexible. For ordinary conditions, the series operation described above should give the most satisfactory results. However, parallel operation is possible, with each set of agitators, clarifier and carbonation basin composing a unit. Ample provision has been made to bypass any portion of the plant.

The rapid sand filters in the filter building are four in number, each 9 feet wide by 14 feet 2 inches long, and an 18 inch layer of gravel topped with a 30 inch sand layer comprises the filter medium. The underdrain system for each filter consists of 2 inch perforated cast iron laterals spaced on 8-inch centers, and feeding a 10-inch cast iron collection header on the center line of each filter. Two concrete wash troughs, spaced 4½ feet apart, are provided for each filter. Water necessary to backwash the filters is obtained from a five thousand gallon steel wash water tank in the tower of the filter plant.

The filtered water flows by gravity to a covered clearwell 17 feet wide by 19 feet 8 inches long by 22 feet 9¾ inches deep, from where it is pumped to the two million gallon storage reservoir for distribution. Chlorination occurs immediately after the water leaves the clearwell.

The filter building is most attractive in appearance, and is arranged very compactly. The basement acts as a pipe gallery, and in it may be found the necessary piping and valves for filter operation. The two Dorrco pressure pumps, filtered water centrifugal pumps, and carbon dioxide generating plant are in the basement.

On the main floor are the four International filter-operating tables, the lime and soda-ash dry feed machines of International Filter Company manufacture, the basin level regulator, flow meter, two chlorinators, electrical control apparatus, sludge recirculation control box, and the laboratory.

Chemicals required for plant operation are delivered by rail from an adjacent spur to an unloading floor, and an electric elevator removes them to the chemical storage room, which is the second floor of the filter building.

As the main purpose of the Boulder City water treatment plant is to deliver a potable water during the seven year construction period

of Hoover Dam, it was at first thought a simple coagulation-filtration plant would be entirely satisfactory. However, a careful study of the water to be treated indicated it economically desirable to go to water softening.

Colorado River water is very hard. Analyses made over a period of two years in the vicinity of Boulder Canyon indicated an average total hardness of 367 p.p.m. (as $CaCO_3$), and an average non-carbonate hardness of 209 p.p.m. The total hardness has been known to reach 636 p.p.m. of which 400 p.p.m. was non-carbonate. Naturally, such a hard water would be both unsatisfactory and uneconomical to use without softening. Life of clothing requiring laundering would be short, time and labor expended in laundering, dishwashing, bathing, etc., would be much greater than if soft water were provided. Plumbing costs would be increased; and the most tangible item is the large soap wastage when hard water is used.

It is estimated that at Boulder City, assuming an average population of 4000, and softening from 367 to 125 p.p.m. hardness, a soap saving to the consumers of $28,300 yearly will be realized. The average chemical cost to produce this water is estimated at $21,900 per year. Thus, a net saving per year of $6,400, or $1.60 per person, per year, over the cost of softening will be realized. For this reason alone, notwithstanding the numerous other benefits to be derived, water softening was considered most desirable for this community.

The pretreatment works were placed in operation August 27, 1931. The water was chemically treated at the River, with sodium aluminate and alum, chlorinated, and delivered to the consumer. This water has constituted Boulder City's supply for the past few months. Although of low turbidity, the high hardness, together with the heavy chlorine dosage necessary to carry the proper residual, caused some complaint. One inhabitant of Boulder City told the writer that his monthly soap bill for himself, wife and two small children, varied between $5 and $10.

The softening plant was completed and started delivering water into the mains on March 2, 1932. The raw water on this day showed a turbidity of 6875 p.p.m., and a total hardness of 470 p.p.m. ($CaCO_3$). The filtered water had a zero turbidity, a total hardness of 80 p.p.m. (as $CaCO_3$), and a zero causticity. Needless to say, the effect of the soft water on the consumer was immediately apparent.

From observations made during trial runs it is believed the above plant is capable of delivering a water of even lower hardness than 80

p.p.m., if desired. However, it is felt water of 125 p.p.m. total hardness is entirely satisfactory, and this is probably the lowest limit to which the Colorado River water for Boulder City will be softened.

This particular method of treatment, including two-stage agitation, sedimentation, carbonation and sludge recirculation, was recommended by the Consulting Engineer after a careful study of the water, and existing methods of water softening as practiced throughout the country. It will effect a saving in chemicals, deliver a completely stabilized water, and result in improved operating conditions over the older methods of lime-soda ash softening.

ACKNOWLEDGMENT

The Boulder City water works system was designed and constructed by the United States Bureau of Reclamation. Mr. Burton Lowther, of Denver, Colorado, a Director of the American Water Works Association, was consulting engineer.

PURIFICATION OF SNAKE AND CLEARWATER RIVERS[1]

By W. P. Hughes[2]

Idaho has three purification plants—two on the Snake in southern Idaho located at Twin Falls and Weiser, and one on the Clearwater at Lewiston.

Methods of sedimentation are identical, but other features vary. Many more problems are encountered in the treatment of Snake River, especially due to the excessive growth of algae, and the seasonal variation in the physical and chemical properties of the raw water during the warmer months of the year. While both lime and sulphate of alumina are used for coagulation at Lewiston, the alkalinity of Snake River water is such that only alum is necessary. At Twin Falls there are times of the year that a peculiar taste and odor is present in the water. As a consequence both pre-ammoniation and pre-chlorination has been adopted, with fair, but not entirely satisfactory results in the taste. This plant also has post-ammoniation and post-chlorination. With this system residual chlorine content is carried throughout the distribution system without excessive chlorine taste.

The most recent plant on the Snake River at Weiser, Idaho, has probably carried out the most elaborate improvements for the eradication of tastes. This plant designed and construction supervised by Burns-McDonnell-Smith Engineering Company of Los Angeles and Kansas was placed in operation in January, 1931 with a designed capacity of 1.5 m.g.d. I am indebted to Mr. H. J. Rosson, Assistant Engineer of the above firm, for the following information on description of operation.

DESCRIPTION OF PLANT AT WEISER

Water is pumped from the river into a baffled concrete compartment, where air furnished by two blowers enters the water through

[1] Presented before the Pacific Northwest Section meeting, May 13, 1932.

[2] City Engineer and Water Superintendent, Lewiston, Idaho. Member A. W. W. A and Am. Soc. C. E.

filtros plates grouted into the bottom of the basin. When not in use, the aerator is by-passed, the water flowing directly into the mixer.

Two dry-feed machines are installed on the floor directly above the aerator, and the chemical solutions can be added at the entrance of the aerator, during aeration, or as the water enters the mixer.

The mixing chamber is 15 feet square by 12 feet deep. An impeller-type agitator, driven by a variable speed motor, provides thorough mixing.

There are two covered settling basins of the "around the end" type, each 68 feet long, 20 feet wide, and 12 feet deep. A baffle wall in the center of each basin causes the water to travel 136 feet from inlet to outlet weir.

There are two separate filters, each unit 15 by 17 feet in plan. The beds consist of 30 inches of sand supported by 18 inches of graded gravel. The under-drains are 2½ inch cast laterals set in a cast-iron manifold on 8 inch centers.

Wash water is provided by a centrifugal pump which takes its suction supply from the clear well. The filters are usually washed at such a rate as to provide a vertical rise of 24 to 28 inches per minute.

Two vacuum-type chlorinators are so arranged as to permit post-chlorination, pre-chlorination, or split-chlorination, as desired.

In the design of the plant, particular attention was given to flexibility and ease of operation. All valves are hydraulically operated, and pumps, blowers, and mixer are controlled from a push-button panel near the operating tables. The laboratory is completely equipped for making the usual chemical, bacteriological, and microscopic tests.

Operation of the plant was entirely satisfactory from January until May, 1931. During this period, the only chemicals used were alum and chlorine. In the early part of May, a slight taste became noticeable in the plant effluent. The concentration of microörganisms in the river water increased rapidly, and, as the weather became warmer, taste complaints were numerous. Microscopic examinations showed that the river water was heavily loaded with organisms of the Diatomaciae group—particularly Tabellaria and Asterionella, although a variety of other forms were present. There was also an after-growth of algae in the filtered-water storage reservoir.

On June 10, I was sent to Weiser to assist in the plant operation, and experiment with various methods of treatment for eliminating

taste and odor. At this time the river water had a pronounced green coloration, and a "swampy" odor could be easily detected in all parts of the plant. After a filter run, a green scum $\frac{1}{8}$ to $\frac{1}{4}$ inch thick covered the entire sand surface. The following test results were obtained on the raw water:

	p. p. m.
Turbidity	20
Color	20
Alkalinity	164
Soap hardness	160
pH	8.0
Microörganisms	20,000 standard units per cc.
Presumptive test for B. coli	80 percent of 1 cc. sample positive

The plant was shut down for a day and the settling basins, mixer, and aerator drained and thoroughly cleaned. The filter beds were scraped, treated with a copper sulphate solution, and washed repeatedly. The storage reservoirs were cleaned, and treated with copper sulphate. As there are two storage reservoirs, it was not necessary to discontinue the water supply to the city at any time.

On June 18, two ammoniators were installed and various combinations of the ammonia-chlorine treatment tried. The best results with this treatment were obtained by applying the ammonia and chlorine to the raw water and carrying a residual through the entire plant—0.2 to 0.3 p.p.m. of chlorine being indicated by the orthotolidine test in the laboratory tap. A noticeable taste persisted in the treated water.

On June 27 the method of treatment was changed. The raw water was heavily chlorinated, the dosage being varied so as to obtain a residual of 0.8 p.p.m. at the entrance to the settling basins. From 0.3 to 0.5 grain per gallon of powdered activated-carbon was applied in the filter-influence lines to remove the excess chlorine and to adsorb taste-producing compounds.

The method of handling the carbon was somewhat similar to that used by E. A. Stearns, of Hamburg, New York. An ordinary dry-feed machine was used, and the solution line of this machine discharged into a 50-gallon steel drum. Water jets placed in the drum kept the carbon in suspension. A 1-inch motor-driven centrifugal pump took its suction supply from the drum and discharged the carbon emulsion through small orifices into the influent lines of the filters. Chlorine and ammonia were added to the filtered water to obtain a 0.2 p.p.m. chlorine residual in the final plant effluent, proportions of chemicals being as follows:

Pro-chlorination	19	lb. per m.g.
Alum	1.0	gr. per gal.
Activated carbon	0.5	gr. per gal.
Post-chlorination	0.7	lb. per m.g.
Post-ammoniation	0.27	lb. per m.g.

Samples of the treated water were compared with samples of treated water taken previously, when only chlorine and ammonia were used, and there was a noticeable improvement in taste. However, the length of the filter runs was reduced 50 percent.

Various combinations of the super-chlorination-activated carbon treatment were tried, and it was found that, when the amount of carbon used did not exceed 0.1 grain per gallon, there was no appreciable reduction in the length of filter runs. On July 6, the use carbon was discontinued entirely, and ammonia and chlorine applied to the raw and treated water. The following day, a taste was noticed in the plant effluent and there were several complaints from various parts of town.

On July 8, activated carbon was again used (0.08 grain per gallon) and no further changes were made until July 20. During this period, there were several days when a slight taste could be detected in the laboratory. In an attempt to increase the amount of carbon which could be used without materially shortening the filter runs, the following changes were made; (*a*) chlorine was applied at the entrance to the aerator, and (*b*) carbon was applied at the entrance to the settling basins.

It was now possible to use as much as 0.4 grain per gallon of carbon with little effect on the length of the filter runs, and a longer contact period was also provided for between the carbon particles and the water. After various trials, the following treatment was found to give best results:

Pre-chlorination	14.3	lb. per m.g.
Alum	0.9	gr. per gal.
Carbon	0.3	gr. per gal.
Post-chlorination	2.0	lb. per m.g.
Post-ammoniation	0.7	lb. per m.g.

The final chlorine and ammonia treatment was varied so as to maintain a chlorine residual of 0.25 p.p.m. at the laboratory tap. By using ammonia, it was possible to maintain a chlorine residual throughout the distribution system without the formation of any chlorinous

tastes; the primary object of carrying a chlorine residual throughout the system being to prevent, or at least retard, any algae after-growths in the storage reservoirs.

This treatment was continued with little variation and there were no further taste complaints. Numerous tests were made daily in the laboratory and no organic or chlorinous tastes could be detected.

CONCLUSIONS

(1) The super-chlorination-activated carbon treatment is the most effective method for removing taste and odors caused by algae in Snake river water at the Weiser filtration plant.

(2) The ammonia-chlorine treatment did not remove algae tastes and odors which were originally present in the raw water.

(3) The use of ammonia in conjunction with chlorine is beneficial as the final step in the treatment process at Weiser, because a chlorine residual can be maintained throughout the distribution system without the formation of chlorinous tastes, and after-growths of algae are prevented, or retarded, in the uncovered distribution reservoirs.

The Weiser filtration plant is now being operated by Albert Olson under the supervision of Lyle Wood, city engineer.

CHLORINATION OF WATER SUPPLIES IN THE STATE OF WASHINGTON

By H. W. Nightingale[1]

The domestic water supplies of the State of Washington are derived, to a considerable extent, from surface sources. Underground sources, though by no means uncommon, are more frequently utilized in the drier eastern portion of the State than in western Washington.

The surface waters are naturally more susceptible to pollution than are underground waters. Pollution of water supplies increases as the population becomes more congested. Although this State is not yet densely populated, a high percentage of surface supplies, especially those drawn from rivers and creeks, shows a varying degree of contamination. In some instances ground waters become polluted even from distant sources, for which reason deep wells cannot be relied upon to consistently produce safe water.

When a watershed is entirely uninhabited, pollution from animal origin often causes the water to fail to meet the standard of not over 2 colon per 100 cc. and not over 100 bacteria at 37°C. During an inspection of a watershed in this State the writer observed 37 dead sheep in a creek feeding the lake source of supply. Since animal contamination may cause paratyphoid fever, due consideration must be given to this form of pollution. Campers and logging camps may cause contamination of creeks and rivers in inaccessible places at the higher elevations near the sources of the streams. For this reason, a clear mountain stream may at any time become an unsafe source of supply. During the past summer an investigation of a polluted water supply in Eastern Washington revealed the fact that excrement had washed into the creek source from a privy located along its banks. Several hundred cases of intestinal disorders were traced to this source of pollution, but fortunately no typhoid.

In some of the rivers of this State pollution enters through the medium of untreated sewage. Modern sewage disposal plants will improve conditions arising from the discharge of raw sewage. Re-

[1] State Sanitary Engineer, State Department of Health, Seattle, Wash.

cently Walla Walla, Sunnyside, Roslyn and Auburn installed such plants, and other cities and towns will shortly follow.

Pollution from trade wastes is being controlled by the proper location of the mills and adequate treatment of their wastes. Considerable progress has been made in Washington with the control of pulp and paper mill wastes, which elsewhere have ruined domestic water supplies from rivers, creeks and lakes.

METHODS OF SAFEGUARDING SUPPLIES

The surface water supplies in this State were formerly partially protected from pollution by means of watershed lease and ownership as well as by the patrol system. Such means alone are unsatisfactory and do not properly safeguard the health of the community using the supply. Ground water supplies were protected only by remoteness from sources of pollution and by guarding against surface seepage.

Section 70 of the Rules and Regulations of the State Board of Health requires in part that—"Unless the source of water supply is adequately protected against danger of pollution, the water must be continuously and effectively subjected to a method of purification approved by the State Board of Health. When the degree of pollution is low and the physical characteristics of the water permit, chlorination or some equally effective method is sufficient, provided that an adequate residual is constantly maintained for a period of 10 minutes after contact with the sterilizing agent. Water requiring preliminary treatment prior to sterilization must be adequately coagulated, settled, filtered and sterilized."

According to this regulation an unprotected water supply is a supply into which pollution can enter. Even in instances wherein the municipality owns or leases the entire watershed and can afford a patrol system, the supply is not necessarily protected. Likewise a deep well supply showing intermittent pollution is not considered to be protected.

WATERS NOT REQUIRING PRELIMINARY TREATMENT

If the physical characteristics of a water are satisfactory—that is, low color, no turbidity or odors and the degree of pollution is low, sterilization by chlorination is sufficient. Ground waters in this state very seldom require treatment prior to chlorination. Certain lake and river waters especially at the higher elevations do not require preliminary treatment. Sterilization by chlorination of these waters of low

organic content is efficient and simple to accomplish. The dosage rates of chlorine are low, ranging from 1 to 2 pounds per million gallons of water.

WATERS REQUIRING PRELIMINARY TREATMENT

The surface water supplies, especially when derived from rivers, creeks and, to a limited extent, from lakes, may require preliminary treatment prior to sterilization. The constituents of surface waters in this state which interfere with efficiency of sterilization, and palatability of the waters after sterilization, are soluble and insoluble organic matter as well as oxidizable mineral substances.

Such constituents, when present in sufficient quantities to discolor or cloud the water, are particularly liable to increase the absorption of chlorine (chlorine demand), necessitating a high rate of dosage, often between 4 and 5 pounds per million gallons. In such cases coagulation, sedimentation and filtration (with open gravity rapid sand filters) constitute the necessary preliminary treatment. Very rarely sedimentation alone is sufficient as a preliminary process where the water contains coarse and easily sedimented matter and possesses a low color and organic matters are not in excess. In some instances waters contain inorganic sediment which cannot be removed without filtration. The Nooksack river often contains such sediment, which is called glacial milk or flour—finely divided matter of silicious origin which does not readily settle and requires coagulation with alum and filtration. At the present time there are ten municipal supplies in which rapid sand filtration is being successfully carried on. Of these nine Ferndale, Lynden, Mount Vernon, Kelso, Wenatchee, Dayton, La Conner, Arlington and Bucoda filter river waters. Anacortes filters lake water. The river waters are usually turbid but not high in color. The lake utilized by Anacortes contains algae and a relatively high color. At all these plants the chlorine dosage is relatively low, from 2 to 2.75 pounds per million gallons, and the water is not only palatable but meets the necessary standard of purity.

Soluble and insoluble organic matter, including algae, when present in sufficient amounts to discolor the water, if not removed by filtration, have a marked tendency along with other substances, to produce tastes and odors which are aggravated by chlorination. When using a chlorination rate sufficient adequately to sterilize such waters, complaints frequently arise, and if the rate is lowered in order to

reduce the tastes and odors, inefficient sterilization, with its attendant hazards, results. Such waters are also subject to seasonal changes in organic matter which necessitates a variation of the dosage of chlorine. Ammonia-chlorine treatment is now being introduced with beneficial results in several cities.

EXTENT OF CHLORINATION

At the present time 92 cities and towns sterilize their water supplies by chlorination. On a population basis (1930 United States Census), 60 percent of the entire state uses chlorinated water. Of these 92

TABLE 1

YEAR	TYPHOID			DIARRHOEA—ENTERITIS	
	Cases	Deaths	Rate*	Deaths under 2 years	Rate*
1923	547	78	5.52	129	9.13
1924	435	47	3.27	143	9.97
1925	391	54	3.07	131	8.99
1926	433	47	3.11	115	7.61
1927	288	32	2.04	79	5.05
1928	282	32	2.05	82	5.25
1929	294	34	2.24	71	4.55
1930	252	30	1.93	75	4.80
1931	234	22	1.41	64	4.09

* Deaths per 100,000 population.

cities and towns, fifty-two take their water supplies from rivers, creeks and lakes. Wells are used by twenty-six.

All cities of over 5,000 population, with two exceptions, safeguard their water supplies by chlorination.

At present there are 5 more municipal sterilization plants in operation in the state than there were two years ago.

The typhoid cases and deaths, as well as the deaths from enteritis in children under two years of age, from 1923 to date, in the State of Washington are shown in table 1. The reduction in the case and death rates has to a large extent been caused by increasing application of chlorination for the sterilization of water supplies, and elimination of cross connections.

SUMMARY

If chlorination is utilized for the sterilization of domestic water supplies, with due consideration to the original quality of the water to be treated, the results will be satisfactory.

Every water system in this State should be rated and classified as to source of supply, degree of protection from pollution, physical and chemical characteristics of the water, degree of efficiency of the sterilization process when used, and, incidentally, for palatability.

The Division of Sanitation of the State Department of Health has partially completed such a survey. When completed all municipalities will possess the necessary information to enable them to determine what hazards exist and what steps should be taken to lessen these defects.

"TUNING IN" ON YOUR CONSUMER[1]

By Mary Symms[2]

The expression "tuning in" is a popular phrase today, not only because of its application to the radio, but because it successfully applies to many things, and indicates that we are getting in touch through very simple processes with harmony or discord, melody or static, exactly in proportion to the intelligence displayed in the way we manipulate the dial. In this instance let us consider that this particular dial—this highly sensitized instrument from which we want only harmony, of course,—is your consumer.

Without the required number of tubes and the connection to electric current or a battery, no matter how intelligently we manipulate the dial, there are only troublesome noises and static. In other words, without a high quality of water and proper distribution of this water, we are not ready to "tune in" on the sensitive instrument which I consider applies veritably to your consumer. And so, first of all, we can readily appreciate the extreme necessity for your "radio"—the original quality, distribution and price tag—to be purified water, physical efficiency, and at a price which is fair in order that you may sell your commodity, and keep on selling and re-selling year after year.

What are the present merits of the improved radio? Finer selectivity, purer tone, elimination of static, and beautified cabinets; and millions of dollars are spent to inform you of the vast improvements over wheezy sets of yesterdays when you heard two stations at once, if the static permitted you to hear the program at all, and bass notes of musical instruments were glorified blurs, to say nothing of nondescript cabinets holding the mechanics of the instrument Within the memory of most of us, we carried water from wells—hoping that it was sufficiently pure to protect us from typhoid and other diseases. How many *cents* have you spent this past year to tell the public of improved water?

[1] Secretary to Director of Service of Public Service Commission, Indianapolis, Ind.

[2] Presented before the Indiana Section meeting, March 10, 1932.

To cite an incident which appears to be of humorous nature and yet approaches tragedy, we were emphatically informed one day that a certain water company pumped water directly from the river to this man's home, and then charged him an exorbitant price for water which cost the company not one penny. He promised us in the next breath that he would see that the city government was paid for this outrage. Now this man was certainly not entirely a fool for he owned and managed several respectable rental properties. This is a significant example of lack of information.

I am more convinced every day that the main reason for the increasing number of complaints brought to the attention of the Service Department is because the public is uninformed. What do I mean by that? Simply this: The medium through which your consumers learn what they are getting for their money is largely through misinformation distributed by propagandists through publicity. To constantly remind your patrons of value received, particularly in safe-guarding health and property, would serve to counteract the poisonous influence and political tirades delivered against you by such organizations.

Would you prefer locking the utility door after the horse has been stolen, or informing the public before loss and trouble hound your steps that you have what the people want, and that they are getting more than they pay for? I hope and sincerely believe that no person here is in favor of the former plan; the application of it having proved to create and be responsible for the havoc now present. The greatest enemy in some instances could be your best champion. Who is it? Your own local and state newspapers! They are in business, as you are, for a livelihood, and sensible, practical people rarely bite the hand which feeds them. The organization that molds the opinion of your community and can do more than all of the public meetings added together is your own local newspaper, or other paid publicity. How many countless thousands truthfully say "I see by the papers," and after all, there are not very many of us who are acquainted with local and national problems except from what the press gives us. What would we have known about the world war save for our newspapers? All right, we are in harmony of thought in that capacity, and let me advise now that you tell your consumers what you have—you have nothing to be ashamed of—on the other hand, you can be justly proud of your commodity. Your radio manufacturer did not hide his light under a bushel—why do you?

COÖPERATION WITH BOARDS OF HEALTH

The coöperation available between our State Board of Health and water companies is one of your finest selling points. The safe-guarding of life, the maintenance of public health, is more than the public realizes, or has ever been told.

Let me interrupt this chain of thought sufficiently long enough to relate an interesting story. Recently a boys Sunday School Class took a hike in my home county. While walking they became thirsty, and soon a small stream was discovered and nearly every boy drank from it. Eight members of that class contracted typhoid fever, which proved that the water was contaminated, as my story will disclose. Immediately our State Board of Health, the dutiful watch-dogs of public health, was notified. A record-breaking dash was made by a State Board of Health representative to this locale and proper investigations were made, and impurities found to be present in this small stream. I doubt very much if your local fire departments answer calls for extinguishing fires any faster than this State Board of Health representative answered the call to investigate this unsanitary condition. How many of you have ever heard this particular story before, or others of similar nature which prove the value of the Board of Health to water consumers? There is one water company manager who knows it thoroughly, and possibly there are a few here who read about it in the bulletin published by the State Board of Health. Yet isn't this a fine story? Is it not worth re-telling, and how obviously has someone overlooked his opportunity to inform his public that he protected life and health in his community through this act. To advise the public of such protection is not patting one's self on the back as a braggart. On the contrary, it is only informing patrons what you have done.

You gentlemen must be aware of the coöperation available between your companies and the State Board of Health—*you* know that—but how many of your consumers who monthly pay their water bills know this? How many of them know that they are getting infinitely more than the stipulated charge for service would indicate? Do they know that the health of their children and the lives of the community are safe-guarded by your purification system? I am not answering that—*you* answer it! If your answer is "no" or a half-hearted "yes," you can expect the horse to be stolen some night. In other words, an uninformed public readily believes all propaganda from political demagogues, cranks, and illiterate broadcasters. All business has

undergone a radical change—old methods are taboo—life insurance companies advertise in national magazines and give health hints, then how much more should utilities see the wisdom of forgetting that their business and extraordinarily fine service to the public are local secrets, and let others share in the knowledge. I am not in favor of any legitimate business hiding in the dark, especially if it wants to succeed. And the time for the information to be spread about is not *after* the attacks are made from enemy camps, caused by gross ignorance of facts or malicious intent to destroy, it is *before!* The denial of an accusation is not very effective, but the denial will not be necessary if the public is well-informed. It is a little too late for a few of you to begin a constructive campaign *before* such activities are present in your cities, but for the majority of you, no faction has actively begun to steal the horse out of your barn.

And how because of my association with the Public Service Commission, and in the very department which enables me to get a cross-sectional view of the public and all utilities, I hear the rumblings of the approaching storm, rather faint and non-distinct in some localities, but unmistakably storm cloud mutterings. What are these rumblings of dissatisfaction? Are they based on facts? Unfortunately, they are not, for if they were the rumblings would practically cease to exist. Although I have touched on their causes, I wish to emphasize them by repetition. There are two causes: ignorance of facts because the public has not been informed, and the malicious activities of the ever-present political demagogue who has been keen enough of hearing to note these rumblings of gathering storms, and who has capitalized on them by exciting your uninformed consumer that he is being robbed. It is part of the human make-up that the majority of us will listen attentively to anyone who subtly begins a whispering campaign that our purses are being emptied by grafters. Human nature does not change; it is the same today as it was yesterday. But someone else has been in error long before the whispering campaigns and publicity attacks took place because the public was not informed with sound, irrefutable testimony of what it is actually receiving for its money.

Before citing different examples of methods employed in this state by various water companies, particularly in respect to the matter of public relations, I wish to share with you a definition of the Public Service Commission of Indiana which appears to me as being well-expressed and voiced in timely language. Here it is: "The Public

Service Commission Act was approved by the General Assembly of the State of Indiana as of March 4th, 1913. The purpose of the Act has broad powers. It provides among other things a reasonable rate of return on the reasonable and fair value of property that is used and useful for the public. It removes discriminatory rates and provides classes of rates to all alike." Those words have been aptly expressed by a gentleman who has had his fingers on the pulse of utilities and their patrons since the very origin of this Act.

EXAMPLES OF HANDLING CUSTOMER COMPLAINTS

And now I would like to cite examples of different methods of handling customers' inquiries and complaints as brought to the attention of our office, the Service Department in the Public Service Commission. An Indiana attorney of doubtful financial stability guaranteed the water bill for a residence in a certain city, thereby relieving the tenant of the responsibility of making a meter deposit. The tenant moved away some time later leaving a fair sized water bill. The attorney defaulted and did not pay the bill for the tenant, to which of course the utility was entitled. At a later date another tenant moved in this same property and offered to make a cash deposit for service which was refused by the utility, and the Company did not make the connection. This new tenant had six small children, and as it was essential that they receive water from some source, water was carried from a neighboring well. Soon afterwards one child contracted typhoid fever and died, and a personal investigation by the Chief Director of Service showed that the family was living in filth and squalor. As stated before, the utility was entitled to the money owed by the former tenant or attorney-guarantor, but if the Company did not wish to sue the attorney because of the relatively small account, why deprive the new tenant of water when he had offered to make a cash deposit? This story interests me particularly because of this: Who would have been morally responsible for an epidemic of typhoid? *My* answer to that question may be summed up with the thought that a piece of steel which will not bend may suddenly snap. So it is true of a rule. A company rule which is not capable of being altered to fit occasions, emergencies, or taking into consideration the many different phases relative to its consumers, may likewise snap.

Examples of prompt and efficient investigations on the part of utilities are too common to excite a great deal of interest. It is

only natural that the story above related would stir our imaginations more readily than citing examples of extraordinarily good service. Fortunately there are many, and it is a great source of gratification to the Service Department.

LOW COST OF WATER

The thought has occurred to me that providence has been kind to utilities considering how little information they ever disclose to their consumers, and how shockingly little the patrons know about the great number of fine things you do every year. For instance, can you name a commodity,—*any* commodity,—which can be delivered to your home, any place in your home, and whenever you want it for an average of *8 cents per ton?* Do your consumers know that a commodity which does not have to be carried in homes in buckets, no ashes to be carried out, and no attention paid to it, except the slight turn of a hand to open a faucet, can be bought for a fraction of a percent of the cost of fuel? *Water can!!* What a fine selling point, one which would interest your public, and yet who knows it? In these few minutes I have repeatedly stressed how important it is that you "sell" your merchandise, and it is my honest opinion from my experience in the Service Department that a dissatisfied patron can do infinitely more harm to you than an unpaid account.

Of course, we understand that the success of a utility depends upon its consumers both from the point of view of revenue and the "good will" manifested. It is the latter which interests me most, because all of you pay salaries to people in your offices whose duty it is to maintain a certain standard of revenue. You say frequently that you strive daily to give the best possible service, and that such service is taken for granted. However, your patrons do not have a monopoly on this idea of taking things for granted. As an example, let us say that you buy a dozen eggs every week for 52 weeks from the same grocer, and the quality is uniformly excellent. When you return each week for another dozen, do you extol the merits of the eggs purchased the week before? Possibly one gentleman here would think to make such a remark. Why would you forget to compliment the groceryman for the fine eggs? Because the grocer is only supposed to sell high-quality eggs; he is depended upon to serve you eggs which meet the requirements from a quality standpoint. All right, on one day you receive two bad eggs in the dozen, not because the grocer is attempting to defraud, but through negligence or error on

the part of someone who was careless in the selection before the grocer ever saw them. Do you tell Mr. Groceryman? Of course, you do! You have paid for a dozen strictly fresh eggs, and you did not receive value in return. I believe that this little illustration of the grocer and his merchandise is very comparable to you and your merchandise. You should not be considered cantankerous because you ask for two more eggs and since we are forced to admit that *you* make a mistake occasionally in *your* business, it is only fair that when your consumer feels that he has a just complaint and returns to your office window *to get the other two eggs*, some one in your employ should lend a willing ear immediately to his distress.

The Service Department, of which I am a part, has extended its work throughout the entire state, to the end that the interests of all patrons are efficiently as well as economically served. We are interested primarily in inquiries and complaints; it is ultra-important from our point of view that the best possible public relations be maintained. Our department, capably and conscientiously presided over by the Chief Director of Service, is very anxious to be of utmost service to the State of Indiana in solving wherever possible any difficulties that anyone has relative to service of utilities, and it is a great source of gratification to us when utility consumers recognize the tremendous worth of utilities, and the utilities in turn intelligently handle their consumers.

It is my sincere belief strengthened by several years experience that a well-informed public *through your local paper* is a comparatively happy one, and the reason for many unfounded rumors implicitly believed by many regarding your methods of operation, is because the majority of you guard the simplest facts of your business, as commendable as they are, as rigidly as though a matter of international intrigue. Evidence of the weak spots of such a program is the colossal ignorance of the public toward what you really give them in exchange for a very nominal sum. If it were possible for any of you to "tune in" occasionally on what your consumers tell us for actual facts, you would be astounded and would organize today to inform them of the merits of your commodity.

DESIGN AND OPERATION DATA ON LARGE RAPID SAND FILTRATION PLANTS IN THE UNITED STATES AND CANADA

By Eugene A. Hardin[1]

While engaged on the preliminary designs for an additional filter plant at Detroit, Michigan, the writer began gathering characteristic data on large rapid sand filtration plants in the United States and Canada. Many data were obtained from published articles describing existing plants, plans of a number of plants, and annual reports of various water works. When this information was tabulated, it became evident that to have it accurate, consistent, and complete it would be advisable to solicit the various plant operating superintendents, designers, or water works officials for the information desired. Accordingly, during the fall of 1926 and spring of 1927, a questionnaire was sent out to each known plant in cities of about 100,000 population or over, according to the 1920 census. The water supply statistics given in the 1925 Municipal Index of the American City Magazine and the Filtration Plant Census published in the Journal of the American Water Works Association, August, 1925, were used in making up the mailing list for these questionnaires. Most of the questionnaires were returned filled in and the data received then tabulated. Early in 1928, copies of the tabulation were sent to each plant for checking, filling in missing data or correcting for reconstruction or additions recently made.

The general interest in this information has since become apparent from the number of requests for copies received from water works men in various parts of the world. Therefore, early in January, 1932, I set about to complete it and bring it up to date again, as time permitted, and now make it available to the water works profession in general through the American Water Works Association Journal.

Data on new plants were obtained, the appended bibliography of literature studied and, to assure the correctness and completeness

[1] Designing Engineer, Department of Water Supply, Detroit, Mich.

of the information, copies were sent out again for checking. Some errors or omissions, however, may still exist; if so, it will be considered a favor to have them pointed out. It is believed that the rapid sand plants of considerable size now operating in all cities in the United States and Canada of over 100,000 population in 1930 are now included. As an arbitrary limit to the bounds of the chart the 100,000 population city was chosen. Several interesting large sized plants, such as at East St. Louis, Illinois, Hackensack, New Jersey, Sacramento, California, Saginaw, Michigan, and Wheeling, West Virginia, have been omitted from this tabulation because the cities supplied are smaller than 100,000 population. The Memphis, Tennessee plant was omitted since it is composed of iron removal filters only. If any large rapid sand filter plant in cities of over 100,000 has been omitted, the data will be gladly received.

It should be borne in mind that, while the data on the physical structure remain constant, the operating data will continually vary in the actual running of the plant. Velocities, retention periods and rates of flow are given as of the nominal plant capacity throughout and should be consistent. The raw water analyses, chemical dosages, wash water rates and percentages are in most cases the averages for a considerable operating period. In some cases the limits of variation are given.

It is felt that this information will be generally useful in comparing plants, in determining standard American filter plant practice and possibly as a guide to new design if due allowance is made for the particular conditions met in each case.

We are all greatly indebted to Mr. George H. Fenkell, General Manager and Chief Engineer of the Department of Water Supply of Detroit, Michigan, for giving the opportunity to collect the data and to the various plant officials, operators and designers who have contributed information and whose coöperation has made possible the compilation of the chart that follows.

EXPLANATORY NOTES

Most of the figures in the tabulation need no explanation, but in order to make them more clear, a brief explanation of some of the items of data is given and a short description of each plant, noting characteristics which do not fall within the limits of the tabulation.

Capacity figures are in U. S. gallons throughout.

The raw water characteristics given are those of the water entering the treatment plant.

Chemical feed is designated as "dry" when the chemical dosage is measured in a dry condition and as "solution" when the dosage is of a given concentration of chemical solution measured in a liquid form.

Velocity of mixing for a baffled mix is the rate of flow through the length of travel given; for the hydraulic jump at Cleveland it is the velocity in the jump; for mechanical agitators it is the peripheral speed of the mixing paddle or blade; for tangential mix no velocity is given.

The coagulation basin lengths and widths given are of the water surface, while the depths are either the range of water depth or the deepest water. Some peculiarities in shape are mentioned below.

The velocity in filter influent main or header is the maximum average cross-sectional velocity at nominal capacity flow.

The velocity in filter inlets is the velocity in the smallest cross-sectional area in the connection of filter to the influent main (or header) when the filter is operating at nominal capacity.

The dimensions of filters which are divided into two sand areas by a center wash gullet are indicated thus: 2 @ a x b, whose a is the width and b the length of sand bed in each half.

Nominal capacity of plant is the product of the number of filter units and the size of units in m.g.d.

PLANT NOTES

1. Akron, Ohio. The supply is impounded in 2.39 billion gallon reservoir on Cuyahoga River.

The original installation of filters in 1915 totaled 20 m.g.d. capacity. These filters are 29 ft. long and have underdrain laterals cast in floor under the Wheeler Bottom construction. Ten m.g.d. of additional filters were installed in 1919, whose length is 25 ft., and 20 m.g.d. in 1922, whose length is 29 ft. The last two installations have false slab construction under the Wheeler Bottom.

A mixing chamber and second coagulation basin were added in 1925.

There is 20 m.g. filtered water storage on distribution system.

2. Albany, N. Y. The supply is impounded on Hannacrois and Basic Creeks, storage basin capacity 12 billion gallons. This supply replaced the Hudson River supply in 1931. There is about 100 m.g. filtered water storage on distribution system in three equalizing reservoirs. Albany also has slow sand filters of about 20 m.g.d. total capacity, to be abandoned.

	(1)	(2)	(3)	(4)		(5)	(6)	(7)	(8)	(9)	(10)		(11)	
City	Akron, Ohio	*Albany, N. Y.	Atlanta, Ga.	Baltimore, Md. Old plant	New plant	Birmingham, Ala.	Buffalo, N. Y.	Cambridge, Mass.	Chattanooga, Tenn.	Cincinnati, Ohio	Cleveland, Ohio Division Plant	Baldwin Plant	Columbus, Ohio	D
Population supplied (1930)	255,000	130,000	275,000	804,874		320,000	572,217	113,650(n)	150,000	511,000	1,200,000		315,000	
Date of beginning operation	1915	1931	1887	1915	1928	1904	1926	1923	1887–92	1907	1918	1924	1908	
Date of enlargement	1919–22	—	1923	—		1924–6–8	—	1931	1913–18 1926–31	1929	—		1923	
Source of supply	Cuyahoga River	Hannacrois and Basic Creeks	Chattahoochee River	Gunpowder River		Cahaba River	Lake Erie	Hobbs Brook, Stony Brook, Fresh Pond reservoirs	Tennessee River	Ohio River	Lake Erie		Scioto River	T
Average analysis of raw water (p.p.m.):	(c)	(c)	(c)	(c)		(c)		(c)					(c)	
Turbidity	11–12	1.5	25–4400 Av. 234	10–809		78	0–300	3	155	160 to 400 Av. 300	0–250 Av. 19		76	
Alkalinity	60–72	43	7–24 Av. 13.2	35		66	70	16	57	35	92		161	
pH value—average	7–8	7.6	6.9	7.0		7.5	8.0	6.90	7.4	7.5	7.95		8.0–8.2	
Color	45–49	13	0	5		0	0	35	8	10	0		19	
Mixing chamber:		(p)												
Type of chemical feed	Dry	Dry	Dry	Solution		Solution	Dry	Dry	Solution	Solution	Dry	Solution	Solution	
Alum added (grains per gallon)	1.90	1.5	0.59	0.8	0.8	0.59	0.2 to 0.9	1.4	1.13	1.40 $FeSO_4$	0.8 to 2.0	0.8 to 2.0	2.1	
Lime added (grains per gallon)	0.37	0	0.26	0.4	0.4	0.66	0	0	0.02	0.75	0	0	6.5$Ca(OH)_2$ 3.5 $NaCO_3$	
Time of mixing at nominal capacity (minutes)	2	20	30	36	30	10	0.8	1	2	1	39	1	60	
Velocity at nominal capacity (feet per minute)	90	60	50	78	78		90	20	37	340	21	600 to 700	88	
Length of travel (feet)	180	1200	1664	2800	2332	—	75	14	75	340	820	30 and 325	5280	
Type of baffling	Around end	Around end	Around end	Around end		None	None	None	—	None	Over and under (g)	Over and under	Over and under	A
Type of mixing	Baffles	Baffles	Baffles	Baffles	Baffles	Mechanical	Pumps	Conduit	Conduit	84″ Conduit	Baffles	Hydraulic jump	Baffles and mechanical	
Head loss in mixing (feet)	1.5	3.0	0.8–1.3	3.3	3±	0	0	0	0	0.6	0.4	2.4	3.3 at 30 m.g.d.	
Coagulation basins:														
Number of basins	6	3	4@2MG 1@5MG(a)	2	2	1	2	2	3	3 (a)	6	4	6	
Time of coagulation at nominal capacity (hours)	2.0	2.25	7.5	2.5	3.5	19.5	3.0	1.6	4.3	3.75	3.4	4.67	6.67	
Velocity at nominal capacity (feet per minute)	2.1	1.5	0.67	4.3	3.8	0.5	1.7	1.5	0.7	1.4	2.8	2.4	2.5	
Method of baffling	Around end	Perforated brick wall		Around end		Slotted entrance	Training walls	Perforated board entrance	None	None	Around end	None	Around end	
Turbidity of settled water (p.p.m.)	6	0.5	13	5	5	14	20	4	14	18	5	3	1	
Basins open or covered	Covered	Covered	Open	Open	Open	Open	Covered	Covered	Open	Open	Covered	Covered	Open	
Length of one basin (feet)	125.25	196	400	317	330±	535	304	137	175	400	221.6	650	200	
Width of one basin (feet)	54.33	50	120	232	1 @ 264± 1 @ 250±	432	202	48	2 @ 75 1 @ 120	2 @ 200 1 @ 80	142	110.25	100	
Depth of one basin (feet)	13	14	24	12.5 to 17	15± to 18±	18	24	16	15	2 @ 23.5 1 @ 16	16.92–17.25	9.25–18.5	20	

TABULATION OF CHARACTERISTICS OF RAPID SAND

In North American Cities of Over 100,000 Po

	(11)	(12)	(13)	(14)		(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
	Columbus, Ohio	Dallas, Tex.	*Denver, Colo.	Detroit, Mich. Water Wks. Pk. Plant	Springwells Plant	Erie, Pa.	Evansville, Ind.	Flint, Mich.	Ft. Worth, Tex.	Grand Rapids, Mich.	*Indianapolis, Ind.	Kansas City, Kan.	Kansas City, Mo.	Knoxville, Tenn.	Louisville, Ky.
	315,000	260,700	287,644(n)	1,822,159		122,000	103,151(n)	130,000	160,802(n)	167,000	364,073(n)	121,000	450,000	105,802	307,808(n)
	1908	1930	1925	1923	1931	1914	1912	1912	1912	1912	1920	1909	1928	1927	1909
	1923	—	—	1928	—	1925	1924-31	1918-24	1918-23	1924-30	—	1912-27	—	—	1914-28-29-31
	Scioto River	Trinity River	Marston Lake	Detroit River		Lake Erie	Ohio River	Flint River	Lake Worth	Grand River	White River	Missouri River	Missouri River	Tennessee River	Ohio River
	(c)	(c)	(c)						(c)		(c)				
	76	30-2600 Av. 180	2-40	5-500 Av. 22		20-400	20-530 Av. 140	12	25-650 Av. 115	20	75	100-20000 Av. 2040	100-20000 Av. 2000	228	5-5500 Av. 185
	161	130	60-85	83		92	59	220	75-127 Av. 104	196	233	143	150	63	55
	8.0-8.2	8.1	7.5-8.5	8.1		7.2	7.4	7.5	8.0-8.2	7.6	7.4	8.2	8.0	7.8	6.7-8.5
	19	0	5-8	0		10	0	33	10±	32	48	26	13	55	0
			(p)						(p)						
	Solution	Dry	Dry	Dry	Dry	Solution	Solution	Dry	Dry	Solution	Solution	Solution	Solution	Dry	Dry
	2.1	1.2 $FeSO_4$	0.1-1.0	0.74	0.6	0.2	1.49	0.09	0.8-4.5 Av. 2.14	0.5	1.75	1.12	1.20	2.28	0.65
	6.5$Ca(OH)_2$ 3.5 $NaCO_3$	4.2	0.05-0.50 $Na_2Al_2O_4$	0	0	0	0.48	0	0	5.8	0	0.49	0.57	—	0
	60	17	20	3	17	10	6.7	30	40	30	9.6	10	30	21	
	88	106	20	80	60	6.5	22.4	36	30	100	156	65	Two 90' diam. tangential mixing chambers	120	No mixing chamber
	5280	1800	400	240	—	65	150	1046	1200	3000	1500	650		—	
	Over and under	Around end	Around end	Around end	None	Over and under	Over and under	Over and under	Around end	Around end	None	Around end		None	
	Baffles and mechanical	Baffles	Baffles	Baffles and pumps	Mechanical agitators	Baffles	Baffles	Baffles	Baffles	Baffles	Conduit	Baffles		Mechanical agitators	
	3.3 at 30 m.g.d.	1.5	0.5	1±	0	1.3	0.75	1.0-1.25	1±	1.0	2.2	0.4	3.5	1.4	
	6	4	1	2	4	2	4	3	3	4	2	3 (a)	5 (a)	2	2 (a)
	6.67	12	1.0	2.0	2.25	2.5	4.75	6.0	5.5	2.5	6.6	33	12.5	8.0	2.0
	2.5	0.75	12.0	4.2	2.5	1.2	3±	2 @ 2-3 1 @ 3-4	1±	1.6	0.75	2.5	0.6	0.4	5.7
	Around end	None	None	Around end and distributing vanes	Slotted entrance and guide vanes	Down baffle in center	Around end	Around end	Around end	Around end	None	None	None	Fence of slats at inlet	Around end
	1	5-25	3-45	11	10-15	2-20	8.3	10-15	5-25	20	10	22	33	9	25
	Open	Open	Open	Covered	Covered	Covered	Covered	Covered	Open	2—Open 2—Covered	Open	Open	Open	Open	Open
	200	2 @ 230 2 @ 407	172.66	360	335.83	182	89	2 @ 175 1 @ 220	2 @ 130 1 @ 173	116.75	295	201	3 @ 309 2 @ 254	175.5	340.5
	100	2 @ 148 2 @ 166	166.67	240	135.5	51	Varies	2 @ 100 1 @ 140	2 @ 85 1 @ 99	88.5	100	304	3 @ 333 2 @ 259	1 @ 143 Av. 1 @ 51 Av.	80.5
	20	18	13.42	16	18	24	29.5	2 @ 14.5 1 @ 13.5	15	13.5	13.5	21-25	17	25	17.5
	15	18	8.8	20	20	8.33	8.56	7	14	6	8.13	34	12	5	10

OF CHARACTERISTICS OF RAPID SAND FILTRATION PLANTS

N NORTH AMERICAN CITIES OF OVER 100,000 POPULATION

	(22)	(23)	(24)	(25)	(26)		(27)	(28)	(29)	(30)		(31)		(32)	(33)	(34)	
, Kan.	Kansas City, Mo.	Knoxville, Tenn.	Louisville, Ky.	Miami, Fla.	Minneapolis, Minn. Columbia Heights Plant	Fridley Plant	*Montreal, Que.	Nashville, Tenn.	New Orleans, La.	Norfolk, Va. Moore's Bridges Plant	Lake Prince Plant	Oakland, Cal. San Pablo Plant	San Leandro Pl.	Oklahoma City, Okla.	Omaha, Neb.	Paterson, Passaic and Little Falls, N. J. District	*Phi Que La Pl
0	450,000	105,302	307,808(n)	110,514(n)	480,000		750,000	153,153(n)	455,792(n)	135,000		500,000		185,383(n)	216,000	550,000	
	1923	1927	1909	1925	1913	1927	1918	1920	1909	1899	1923	1921	1927	1906	1923	1902	19
7	—	—	1914-28-29-31	1926	1914-20	1928	1927-30	—	1924-31	1921	—	1930	1930	1923	—	1919	192
River	Missouri River	Tennessee River	Ohio River	Wells	Mississippi River		St. Lawrence River	Cumberland River	Mississippi River	Four Lakes	Lake Prince	Mokelumne River		North Canadian River	Missouri River	Passaic River	Sch
										(c)	(c)	(c)	(c)	(c)		(c)	
00 0	100-20000 Av. 2000	228	5-5500 Av. 185	0	2-95 Av. 6.8		15	230	75-2350 Av. 700	45	18.5	50	40	20-400 Av. 100	150 to 22000	3	
	159	63	55	230	80-210		65	60	93 Av.	41.6	45.8	45	55	30-250 Av. 150	95-220	31	
	8.0	7.8	6.7-8.5	Hardness 272	7.5		7.5	8	7.4-8.2	7.0	7.15	7.5	7.5	8.0	7.8	7.2	
	13	35	0	50	20		18	50	12	67	50	5	5	85	10±	37	
				(p)		(p)			(d) 1909 / (d) 1926-28				(p)	(p)			
n	Solution	Dry	Dry	Solution	Dry and solution	Dry	No mixing chamber	Dry	Solution	Solution	Alum—solution Lime—dry		Dry	Alum—solution Lime—dry	Alum—solution Lime—dry	Dry	
	1.20	2.28	0.65	1.0	0.15-6.5	0.15-6.5			0.75 $FeSO_4$	0.75 $FeSO_4$	1.49	1.56	0.9	0.6	0.36	0.25 to 4.25	1.5	1.
	0.57	—	C	11.9	0	0			4.96	4.98	0.69	0.40	0.3	0.3	8.0	0-1	0	C
	30	21		15	3	6		40	60	60	1	10	8	16	30			
		120		60	49	29		48	85	84	60	40	90	120	36			
		—		—	120	118		—	5120	5056	60	400	720	—	1080			
nd	Two 90° diam. tangential mixing chambers	None	No mixing chamber	None	Over and under	Over and under		None	Over and under (g)	Around end	Over and under	Over and under (g)	Over and under	None	Over and under		No mixing chamber	No mixing chamber
		Mechanical agitators		Mechanical agitators	Baffles			Mechanical agitators	Baffles	Baffles	Baffles		Baffles	Mechanical	Baffles			
	3.5	1.4		2 (p)	0.75	0.75		0	1.5±	1±	—	—	1.5	0.2	2.0			
												(p)						
	5 (a)	2	3 (a)	1—Clarifying 1—Settling	6 (a)	2	No coagulation basins	2 (a)	4 (a)	4 (a)	2	2	2	2	4	6 (a)	2	4 (
	12.5	8.0	2.0	2—Clarifying 1—Settling	3.6	2.3			18	16	4.5	5.0	3.0	2.7	4.0	4.0	4.3	3.
	0.6	0.4	5.7	0.9 Clarifying 2 Settling	1±	7.0		1	0.55	0.52	1.5	1.5	1.67	1.1	0.83		3±	1.
	None	Fence of slats at inlet	Around end	Under baffle at inlet	Around end	Around end		None — Perforated inlet	Around end	Around end	Slotted wall	Around end	Diffusor wall		Slotted inlet		(d) 1902 Around end / (d) 1919 None	Submerged
	33	9	25	1	4	4			13	13	9	6	15	15	12	24	2	4
	Open	Open	Open	Open	Covered	Covered		Open	Open	Open	Open	Open	Open		Open	Open	Open / Covered	Op
	3 @ 309 2 @ 254	175.5	340.5	109 Clarifying 120 Settling	4 @ 131.5± 2 @ 130.8	192.5			345	380	400	230	300	200	190		310	144	29
	3 @ 333 2 @ 259	1 @ 143 Av. 1 @ 51 Av.	80.5	109 Clarifying 60 Settling	2 @ 193.3 4 @ 95.67	167			250	368	75±	74	50	50	2 @ 40 2 @ 50		110	44	8
	17	25	17.5	17	16	16			13.75	13.75	12±	10	13	13	12		20	43	12.

(34)	(35)		(36)	(37)	(38)		(39)	(40)	(41)	(42)	(43)	(44)	(45)	(46)	(47)	(48)	
a, Passaic ttle Falls, District	*Philadelphia, Pa. Queen Lane Plant	Belmont Plant	Providence, R. I.	Richmond, Va.	St. Louis, Mo. Chain of Rocks Plant	Howard Bend Plant	St. Paul, Minn.	Tampa, Fla.	Toledo, Ohio	*Toronto, Ont.	Trenton, N. J.	Tulsa, Okla.	*Washington, D. C.	*Wilmington, Del.	Windsor, Ont.	Youngstown, Ohio	
0,000	1,954,000		335,000	225,000	490,000	335,000	271,606	101,334(n)	350,000	621,596	122,610(n)	141,281(n)	515,000	110,168	115,000	132,358	186,316
902	1922	1929	1926	1924	1915	1929	1923	1926	1910	1916	1914	1929	1927	1917	1926	1905	1932
919	1925-26	—	—	—	—	—	—	—	1913-21-22	—	—	—	—	1926	—	1914-25	—
River	Schuylkill River		Scituate Reservoir	James River	Mississippi River	Missouri River	Mississippi River	Hillsborough River	Maumee River	Lake Ontario	Delaware River	Spavinaw Lake	Potomac River	Brandywine Creek	Detroit River	Mahoning River	Meander Creek
(c)			(c)					(c)				(c)		(a)			(c)
3	74-251		2.2	0-2000	1430	1900	8	1	190	1-175 Av. 6	0-1000	5-1000 Av. 15	10-2500	30	3-800 Av. 35	45	15
1	49		5	46	132	138	145	82	142	94	60	65-100 Av. 80	30-95 Av. 70	41	86	40	65
.2	7.3		6.4	7.4-8.1	7.95	8.05	7.3	7.2	7.8	7.65-8.2		7.5	7.8	7.2-8.6	8.0	6.5	
7	9		25	38	25	15	21	79	35	0	10-100	6-200 Av. 14	0	26	0	37	25
			(p)				(p)					(p)					
ry	Solution		Dry	Dry	Solution	Dry	Solution	Dry	Alum—solution Lime—dry	Solution	Dry	Dry	Dry and solution	Solution	Dry	Dry	Dry
.5	1.28	1.12	0.75 $FeSO_4$	2.94	1.2 $Al_2(SO_4)_3$ 1.0 0.73 $FeSO_4$ 0.5		0.5-1.25	2.7	2.58	0.65	0.4-4	0.2-3.5 Av. 0.3	1-3 Av. 1.3	0.9	0.6	0.7	0.5
0	0	0.20	1.21	0	4.7	6.0	0	2.6	0.5	0	0	0	0.6	0	0	5.5	2—Soda 5—Lime
	No mixing chamber	30	4.6 (k)	10	45	16	33	30	30	2±	No mixing chamber	22	27	7	3.8	No mixing chamber	25
		4.1	One 35' diam. tangential mixing chamber (k)	45	106	Tangential mixing chambers	13	—	40	78-630		Two 40' diam. tangential mixing chambers	60	24	25-60		—
		123		450	4760		430	—	1243	417 in pipe			1600	150	49.5		—
		Over and under		Over and under	Around end		Over and under	Down baffles	Around end	None			Around end	Around end	Over and under		None
		Baffles		Baffles	Baffles		Air and baffles	Mechanical agitators	Baffles	Pumps and conduit			Baffles	Baffles	Baffles and pumps	Pumps	Mechanical agitators
		0.5	1.0	1.4	2.5	0.5±	0.5	0	2.0	0		0.67	0.5-2.0	0.1	0.1	0	0
2	4 (a)	2 (a)	2	4 (a)	6 (a)	2 (a)	2 (a)	4	3	No coagulation basins	2 (a)	2 (a)	2 (a)	2 (a)	2	2	4
3	3.8	2.1	62.5	100	36	8.7	3.8	6.0	8.0		3.0	3.0	3.0	(d) 1917 4.0 (d) 1926	2.0	7.5	2.0
±	1.2	1.2	1.1	6.0	1.5	2.3±	3	0.5	1-2		1±	0.8	3.7	0.7 1.4	2.3	1.6 and 2.2	0.8
	(d) 1919 None	None	Around end	Around end-also mechanical stirrers	Series basins and weirs	None	Around end	Around end	2—Around end 1—straight flow with perforated inlet		Vertical baffles	None	Around end	Around end None	None	Over and under (z)	None
	Submerged inlet wall																
2	4	9	1	8	9	5	5	0	12			2-15	4-8	11 11	10	5	
	Covered	Open	Open	Open	Open	Open	Covered	Open	Covered		Covered	Open	Open	Covered Open	Covered	Open	2—Open 2—Covered
	144	290	150-170	1 @ 800 1 @ 1300	320	400	330	220	108	500		209	151	232	157 160	124	200	95
	44	80	115-80	1 @ 550 1 @ 850	120	670	406	110	78	2 @ 100' 1 @ 120'		62	102	150	98 55	50	150	95
	43	12.25	11.3	1 @ 9.4 1 @ 11.4	10	15.9-23	15	15-19	15	18		19.5	6.5-14	12-17	9 15	20	19	12

Velocity at nominal capacity (feet per minute)	2.1	2.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
Method of baffling	Around end	Perforated brick wall		Around end		Slotted entrance	Training walls	Perforated board entrance	None	None	Around end	None	Around end	None	
Turbidity of settled water (p.p.m.)	6	0.5	13	5	5	14	20	4	14	18	5	3	1	5-25	
Basins open or covered	Covered	Covered	Open	Open	Open	Open	Covered	Covered	Open	Open	Covered	Covered	Open	Open	
Length of one basin (feet)	125.25	196	400	317	380*	535	304	137	170	400	227.5	093	200	2 @ 407	
Width of one basin (feet)	54.33	50	120	232	1 @ 264* 1 @ 250*	432	202	48	2 @ 75 1 @ 120	2 @ 200 1 @ 80	142	110.25	100	2 @ 148 2 @ 166	
Depth of one basin (feet)	13	14	24	12.5 to 17	15* to 18*	18	24	16	15	2 @ 23.5 1 @ 16	16.92-17.25	9.25-18.5	20	18	
Total basin capacity (million gallons)	4	3	13	13.5	1 @ 8 1 @ 8.6	35	20	1.5	2 @ 1.3 1 @ 2.3	2 @ 10 1 @ 2	21	32.8	15	16	
Coagulated water conduits:													(o)		
Velocity-filter influent main (feet per second)	1.0	1.38	3.42	2.0	0.65	3.4	4.0	1.33	3.1-7.2	3.9	2.2	2.17	2.0	2.9	
Velocity-filter inlets (feet per second)	2.25	1.0	1.48	1.97	1.97	2.2-2.8	2.84	1.33	1.4-2.8	2.8	2.94	2.04	0.65	1.2	
Filters:															
Rate of filtration (m.g.a.d.)	125	125	125	125	125	125	125	127	125	156	125	125	125	120	
Number of units	25	8	7 (e)	32	28	62	40	16	20 (h)	28	36	40	18	16	
Size of units (m.g.d.)	2	4	3 (e)	4	4	38 @ 0.5 24 @ 1	4	1.4	1	5	4.16	4.16	3	2	
Dimensions of sand bed (feet)	2 @ 12 x 29 2 @ 14 x 25	2 @ 15.25 x 46.5	2 @ 12.37 x 42 (e)	2 @ 13 x 54	26 x 54	38 @ 15' dia. 24 @ 16 x 22	2 @ 14 x 50	24 x 20	16 x 22'	2 @ 14 x 50	2 @ 14.83 x 49	2 @ 14.83 x 49	2 @ 11.5 x 47	2 @ 13 x 28	23
Depth of filter box (feet)	8.5	12.25	11	9	9	38 @ 10 24 @ 12*	9	9	9	10.75	13.58	13.50	11	10.75	
Thickness of sand (inches)	30	30	28	24	24	30	26	27	30	30	27	30	24	30	48
Effective size sand (millimeter)	0.40	0.33	0.34	0.60*	0.60*	0.45	0.38-0.45	0.51	0.42	0.42	0.48	0.38	0.41	0.40-0.45	
Uniformity coefficient sand	1.29	1.75	1.5	1.2*	1.2*	1.5	1.5	1.54	1.5	1.42	1.50	1.70	1.60	1.60	
Thickness of gravel (inches)	10	18	21	14	18	12	16	9	15	14	22	22	18	18	
Maximum size of gravel (inches)	½-¼	2½	1½	3	3	1	2½	1	½	1½	1½	1½	2½	2	
Minimum size of gravel (inches)	12 mesh	10 mesh	⅛	¼	¼	¼	⅛	⅛	¼	⅛	10 mesh	⅛	¼	¼	
Type of strainer system	F	C	B	A	E	H	B	F	H	A	B	B	A in 10 B in 8	B	
Rate of wash (inches per minute)	21	24	24	24*	24*	19	30	20-27	20	22	24-29	24-36	18	15-20	
Agitation of sand	No	No	No	No	No	No	No	No	No	No	No	No	No	No	
Height-top of sand to crest of trough (inches)	21	27	24	24	30	18 to 15	26	24	18	24	30	25	24-14.5	24	
Clear distance between troughs (feet)	4.47	4.67	3.25	4.85	3.92	5.75-3.25	4.25	2.50	8 @ 5.5 12 @ 3.0	7.0	6.0	4.93	6.0	5.0	
Location of wash gullet	Center	Center	Center	Center	Side	Front	Center	Front	Front	Center	Center	Center	Center	Center	
Wash water tank capacity (thousand gallons)	70	252	435	248	242	106	280	175	212	843	460	2 @ 212	104	0	
Tank bottom above sand surface (feet)	32.25	26.25	7.42	22.5	22.5	24.6	48	0	6	34.5	35	44.1	20.17	—	
Percent wash water—average	2.5-3	2.5	1.3	1.8	2.0	2.0	2.5	3.6	1.52	1.75	2.36	2.08	1.0	1.5	
Filtered water reservoir:								(p)							
Open or covered	Covered	Covered	Covered	Covered	Open	Open	Covered	Covered	Open	Open	Covered	Covered	Covered	Covered	C
Capacity (million gallons)	1 (b)	2 (b)	10	15 (b)	6.4 19.4	3	18 (b)	4 (b)	1.3 (b)	19.6 (b)	20 (b)	135.8	16 (b)	5 (b)	
Nominal capacity of plant (m.g.d.)	50	*32	42	128	112	43	160	22.4	27.5	140	150	165	54	32	

TYPES OF STRAINER SYSTEMS

A—Perforated brass plates over ridge and valley bottom.
B—Manifold with perforated pipe laterals.
C—Manifold with pipe laterals and brass strainers.
D—Wagner bottom.
E—Wooden slat grid.
F—Wheeler bottom.
H—Perforated false bottom slab with strainers.
G—Half-round C. I. Pipe raised ¼ inch from floor leaving slot orifice between edge of pipe and

* Also has a slow-sand plant in operation.

None	None	Around end and distributing vanes	Slotted entrance and guide vanes	Down baffle in center	Around end		Around end	Around end	Around end	None	None		None	Fence of slats at inlet	Around end			Down baffle at inlet	Around end	Around end
5–25	3–45	11	10–15	2–20	8.3		10–15	5–25	20	10	22		33	9	25			1	4	4
Open	Open	Covered	Covered	Covered	Covered		Covered	Open	2—Open 2—Covered	Open	Open		Open	Open	Open			Open	Covered	Covered
5 @ 188 2 @ 407	174.33	305	338.33	182	89		2 @ 175 1 @ 220	2 @ 130 1 @ 173	118.75	295	201		3 @ 309 2 @ 254	175.5	340.5			100 Clarifying 120 Settling	4 @ 131.5 2 @ 120.8	192.5
2 @ 148 2 @ 166	166.67	240	135.5	51	Varies		2 @ 100 1 @ 140	2 @ 85 1 @ 99	88.5	100	304		3 @ 333 2 @ 259	1 @ 143 Av. 1 @ 51 Av.	80.5			100 Clarifying 90 Settling	2 @ 193.3 4 @ 95.67	167
18	13.42	16	18	24	28.5		2 @ 14.5 1 @ 13.5	15	13.5	13.5	21–25		17	25	17.5			17	16	16
16	2.0	29	25	3.33	3.56		7	4.5	4	3.33	34		52	5	10			1.5 Clarifying 0.9 Settling	4.7	7.8
																		(o)		
2.9	2.0	3.8	0.9		0.6		1.0–3.0	2.5	2.5	1.17	3.0		2.5	3.05	0.11			1.0	3.0	1.4
1.2	1.7	1.97	0.88		1.5		2.0	1.8	2.2	0.775	1.0		2.84	2.75	2.3			2.75	2.3	1.90
					(d) 1924	(d) 1931					(d) 1912	(d) 1927			(d) 1931	(d) 1914	(d) 1928			
120	156	160	160	125	125	130	120	120	118	120	125		125	125	125	125	125	125	125	125
16	14	80	68	16	4	12	28	12 10	20	6	9	5	24	6	6	12	8	8	16	20
2	4.5+	4	4	2	1.5	1	1	1.25 2	2	2	1.33	2.66	4	2.5	6	3	5	2.5	3.25	4
2 @ 13 x 28	23 x 54.33	32 x 34	27 x 40.33	712.5 sq. ft.	21 x 25	16 x 21	16 x 22.5	2 @ 9 x 25 2 @ 13.25 x 28.67	20.5 x 36 20.5 x 42	20.75 x 34.75	16 x 30	2 @ 16 x 30	2 @ 14 x 50	2 @ 13.1 x 33.5	52.67 x 40.5	23 x 47	42 x 50	2 @ 10 x 41.75	2 @ 11.5 x 51	35 x 4
10.75	11.75	10.5	11	10	8.5	8.28	7	6.25	8	10.08	10.82		9.75	10	10	10	10	11	10	10
30	48 (coal)	30	20	30	36	18	25 to 30	27	18	24	26	24	27	30	30	26	30	30	30	30
0.40–0.45	0.62	0.45	0.48	0.40	0.52	0.5	0.44	0.37	0.35	0.45	0.39		0.41	0.47	0.41	0.42	0.475	0.45	0.35–0.44	0.40
1.60	1.99	1.60	1.30	1.7	1.2*	1.5	1.5	1.86	1.65	1.2	1.62		1.55	1.68	1.30	1.30	1.30	1.45	1.65	1.53
18	15	17	18	12 @ 10 4 @ 18	30	18	10–16	18	16	24	14	18	18	24	24	14	24	34	17	18
2	¾	2	3	2½	2	2½	2	2½	2½	3	2–2½		2	1½	2	1½	2	2½	3	2½
¼	0.05	⅛	⅛	⅛	¼	10 mesh	¼	⅛	¼	10 to 30 mesh	10 mesh		½	¼	10 mesh	10 mesh	10 mesh	10 mesh	10 mesh	10 mesh
B	B	C	B	H	B	B	C	B	A in 15 D in 5	B	A	B	B	B	B	C	B	B	A	B
15–20	12–20	26–30	30–36	22–30	24	24	18	21	20	24	24		24	24–30	22 to 36			24	24	18–24
No	Air	No	No	No	No	No	No	No	No	No	No		No	No	No	No	No	No	No	No
24	48	30	40	30	24	25	24–17	24	18	27	27	24	24	24	24	25	24	25	24	24
5.0	9.33	5.83	4.44	5.5	5.0 4.0	4.5	3.17	5.0	4.0	3.62	4.79		4.33	5.0	5.08	5.17	6.5	5.0	5.0	4.5
Center	Side	Front	Front	Center	Front	Front	Front	Center	Side	Front	Side	Center	Center	Center	Center	Front	Center	Center	Center	Front
0	150	140	95	113	144		0	50	235	125	100		150	150	125		300	100	125	125
—	44.85	29	35.5	75	8		—	20	22	20	40		22	38	42		37	22	35	37
1.5	1.4	2.0	1.3	1.75	5.11		2.0	1.73	1.5	1.33	2.0		1.37	1.2	2.0			1.2	1.59	2.1
Covered	Covered	Covered	Covered	1—Open 2—Covered	Covered		Covered	Covered	Covered	Covered	Covered		Covered	Covered	Covered			Covered	Covered	
5 (b)	6	55 (b)	40 (b)	33 5.7	1.9 (b)		10 (b)	5	8.5 (b)	15.5	1 (b)		3 (b)	0.5 (b)	20 (b)			5 (b)	45	1
32	*64	320	272	32	18		28	35	40	*12	25		96	15	120			26	52	

SYSTEMS

edge of pipe and floor.

	33	9	25		1	4	4	No coagulation basin	inlet	13	13	9	6	15	15	12	24	2			
	Open	Open	Open		Open	Covered	Covered		Open	Open	Open	Open	Open	Open		Open	Open	Open	Covered		
	3 @ 309 2 @ 254	175.5	340.5		109 Clarifying 120 Settling	4 @ 131.5[a] 2 @ 120.8	192.5			345	380	400	230	300	200	190		310	144		
	3 @ 332 2 @ 259	1 @ 143 Av. 1 @ 51 Av.	80.5		109 Clarifying 60 Settling	2 @ 193.3 4 @ 95.67	167			250	368	75[a]	74	50	50	2 @ 40 2 @ 50		110	44		
	17	25	17.5		17	16	16			13.75	13.75	12[a]	10	13	13	12		20	43		
	52	5	10		1.5 Clarifying 0.9 Settling	4.7	7.8			30	47	3	2.5	3	2	2.67	80	5.7	1.8		
					(o)											(o) (j)					
	2.5	3.05	0.11		1.0	3.0	1.4			1.55	1.37	4.73	1.5 to 2.5	1.0	0.75	1.97	1.2	1.3	0.4		
	2.84	2.75	2.3		2.75	2.3	1.96	2.8		2.85	2.85	1.9	3.0	1.16	1.16	2.0	2.0	2.0	2.0		
(d) 1927			(d) 1931	(d) 1914	(d) 1928																
	125	125	125	125	125	125	125	125	136	125	122	122	136	125	108	108	120	125	120	125	
5	24	6	6	12	8	5	16	20	48	12	10	18	22	12	16	12	8	12	32	10	
2.66	4	2.5	6	3	6	2.5	3.25	4	3.75	2.33	4	4	18–0.67 4–1	1	1.5	1.5	2	4	1	1	
@ 16 x 0	2 @ 14 x 50	2 @ 13.1 x 33.5	52.67 x 40.5	23 x 47	42 x 50	2 @ 10 x 43.75	2 @ 11.5 x 51	35 x 40	2 @ 12 x 50		2 @ 13.5 x 53	2 @ 13.5 x 53	11.5 x 18.5	16 x 22	605 sq. ft.	610 sq. ft.	2–12 x 30	2 @ 14 x 50	15 x 24	348 sq. ft.	2 4
	9.75	10	10	10	10	11	10	10	10		12	13	8	9	11.5	11.5	10[a]	8	10	12	
24	27	30	30	26	30	30	30	30	30	30	30	30	30	30	28	28	26	24	30	30	
	0.41	0.47	0.41	0.42	0.475	0.45	0.35–0.44	0.40	0.55	0.33	0.33	0.33	0.49	0.38	0.6	0.6	0.37–0.42	0.40	0.44–0.47	0.45–0.50	0
	1.55	1.68	1.30	1.30	1.30	1.45	1.65	1.52	1.45	1.65	1.65	1.65	1.59	1.63	1.35	1.35	1.60	1.30	1.40	1.40	
18	18	24	24	14	24	24	17	18	15	18	9	18	15	15	18	22	16	8	12	15	
	2	1½	2	1½	2	2½	3	2½–2½	1½	3	¾	2	2½	2½			2½	¾	2	3	
h	¼	¼	10 mesh	10 mesh	10 mesh	10 mesh	10 mesh	10 mesh	10 mesh	¼	¼	¼	¼	¼			1/16	¼	1/16	1/16	
B	B	B	B	C	B	B	A	B	B	H	A	B	B and C	H	B	B	B	D	C	F	
	24	24–30	22 to 36			24	24	18–24	16	30	24	24	24	24	38	24	24	24	12	27	
	No	No	No	No	No	No	No	No	Air	No	No	No	No	No	None		No	No	Air	No	
24	24	24	24	25	24	25	24	25	14–15	24	33	36	26–28	26–28	30	30	26	22	14	24	
	4.23	5.0	5.08	5.17	6.5	5.0	5.0	4.0	5.0		6.62	6.62	4.17	3.5	5.0	5.0	4.62	3.42	3.0	2.1	3.
Center	Center	Center	Center	Front	Center	Center	Center	Front	Center	Front	Center	Center	Front		Side		Center	Center	Front		
	150	150	125		300	100	125	132	124		120		0	27	80	80	100	300	20		
	23	38	42		37	22	35	36	21.25	50[a]	19.5		—	15.5	49.5	39	40	30.6	58		
	1.37	1.2	2.0			1.2	1.58	2.31	0.5		0.3		3.38	1.42	1.6	2.0	2.1	1.4	2.2		
																	(p)				
ed	Covered	Covered	Covered			Covered	Covered		Covered	Covered	Covered		Open	Covered	Covered		Covered	Open	Covered		
	3 (b)	0.5 (b)	20 (b)			5 (b)	45	16.5	30 (b)	1.3 (b)	20		2.5	3	6 (b)	3 (b)	3.5 (b)	20	3.5 (b)		
	96	15	120			20	52	80	*180	28	40	72	16	12	24	18	16	48	42		

NOTES

a—Also preliminary sedimentation.
b—Also storage on distribution system.
c—Impounded supply.
d—Data given under dates is for portion constructed in that year.
e—Atlanta: Also has pressure filters as follows: 36 pressure—0.5 m.g.d.—A
f—"Drifting sand" filters with cemented gravel.
g—Also around end baffling.
h—Chattanooga: Also 26 pressure filters of 0.11 m.g.d. capacity—Area 38.
j—Also secondary coagulation after settling.
k—Providence: Mixing also in conduit 825 feet long for 15 minutes at a v
m—Providence: No reservoir at filter plant. 39 m.g. reservoir on low ser
n—Population as of 1930 U. S. Census.
o—Also Recarbonation.
p—Also aeration.

		Sub-inlet			rers					Inlet	No coagulation							
2		4	9	1	8	9	5	5	0	12			2–15	4–8	11	11	10	5	
en	Covered	Open	Open	Open	Open	Open	Open	Covered	Open	Covered		Covered	Open	Open	Covered	Open	Covered	Open	2—Open 2—Covered
0	144	290	150–170	1 @ 800 1 @ 1300	320	400	330	220	108	500		209	151	333	157	160	124	260	95
0	44	80	115–80	1 @ 550 1 @ 850	120	070	406	110	78	2 @ 100′ 1 @ 120′		62	102	150	98	55	50	150	66
	43	12.25	11.3	1 @ 9.4 1 @ 11.4	10	15.9–23	15	15–19	15	18		19.5	6.5–14	12–17	9	15	20	19	12
7	1.8	8	3.4	1 @ 31 1 @ 94	7.5	240	29	6.0	3.5	19		3.6	3	10	2		1.7	3.2	3.2
						(j)	(o) (j)		(o)									(j)	
3	0.4	1.0	0.3	0.74	1.29	1.36–2.53	1.94	2.2	1.54	2.4	2.6	1.0	1.93	1.94	0.47		2.5	2.5–3.9	3.15
0	2.0	2.2	2.3	0.92	2.61	2.87	1.42	2.48	0.68	2 0	6″ = 1.26 12″ = 2.36	1.5	1.97	2.9	2.7		2.8	2.84	1.24
0	125	95	100	120	120	125	125	125	125	125	180	125	125	118	118		136	125	135
	10	20	12	10	10	40	20	12	8	56	10	16	6	20	6		10	28	16
	1	2.5	2.5	4.8	3	4	4	3.5	1.75	1	7.2	1.875	4	4	2		2.5	12 @ 1 16 @ 0.89	4
24	348 sq. ft.	2 @ 14.5 x 40	44 x 25	2 @ 16 x 55	30 x 36	2 @ 14 x 50	28 x 50	2 @ 14.5 x 42.25	2 @ 10 x 30	16 x 22.5	1745 sq. ft.	2 @ 13.5 x 24	2 @ 14 x 50	27.35 x 54	2 @ 10.25 x 36		25 x 28	21 x 16.5 21 x 16.75	2 @ 12.25 x 54
	12	9	10	10.5	9	10.5	13.5	11.25	8.5	8.5	14	7	9.5	15	10		8.5	8.5	9.25
	30	30	28	30	27	30	24	27	30	24	108 (f)	30	24	24	24		37	30	27
0.47	0.45–0.50	0.40–0.50	0.40–0.55	0.42	0.40	0.40	0.40–0.50	0.38	0.40	0.38	0.40 (f)	0.52	0.42	0.34	0.45		0.45–0.55	0.39	0.40
0	1.40	1.50–1.70		1.48	1.45	1.65	1.65	1.75	1.6	1.50	2.0 (f)	1.61	1.6	1.6	1.6		1.5	1.41	1.60
	15	18	18	18	16	12	18	16	19	9	9	12	18	16	18		14	18	12
	3	3	2	2	2½	2	2½	2	2½	2	¾ (f)	¾	2½	3	2½		2	2½	¾
	½	½	½	½	10 mesh	½	½	¾	½	¾	¾ (f)	¾	10 mesh	¾	½		¾	10 mesh	12 mesh
	F	B	E	B	B	A	B	E	G	B	B	C	B	E	B		B	C	F
	27	12–15	24–30	19–29	16–20	24	20	24	24	20–24	16	19	24	30	24		19	16–18	36
	No	Air	No	No	No	No	No	No	No	Air	No	Air	No	No	No		No	Air	No
	24	15	22	24	23	24	20	22	27	18	51	12	26	21	24		25	24	30
9	2.1	3.5 and 4.1	4.25	2.83	5.12	4.42	3.73	4.50	4.0	6.0	Special circular gutters	4.50	4.42	4.0	4.0		4.42	6.17	5.1
Front		Center	Side	Center	Center	Center	Side	Center	Center	Front		Center	Center	Side	Center		Front	Front	Center
20		200	59	400	100	2 @ 170	124	16,000	100	60	240	345	133	200	70		0	0	165
58		34	19	23	20	35	30	54	39	23	50.5	15	11.5	54	35.5		—	—	33.3
2.2		1.0	3	2.4	2.1	1.67	1.25	3.0	1.9	2.5	0.81–3.65	3.7	1.5	2.1	1.97		2–3	2.0	
				(p)	(p)														
Covered		Covered		Covered	Open	Covered		Covered	Covered	Covered	Covered	Open	Covered	Covered	Covered		Covered	Covered	Covered
3.5 (h)		50	1 (b)	0 (m)	3 (h)	74 (b)	5 (b)	1.6 (b)	0.5 (b)	21	5.4 (b)	1.2	1 (b)	15 (b)	5 (b)		2.4	1.8 (b)	1.1 (b)
42		*50	*30	48	30	160	80	42	14	56	*72	30	24	*80	*12		25	26	40

NOTES

that year.
ure—0.5 m.g.d.—Area 175 sq. ft.; 12 pressure—0.25 m.g.d.—Area 87 sq. ft. (Hyatt).

apacity—Area 38.5 sq. ft. and 20 pressure filters of 0.23 m.g.d. capacity.—Area 78.5 sq. ft.

5 minutes at a velocity of 55 feet per minute.
ervoir on low service system. 12 m.g. reservoir on high service system.

3. Atlanta, Ga. There is from 7 to 10 days' sedimentation in the raw water storage reservoir.

Filter data given are for the 7 gravity units installed in 1923. There are also 36 horizontal type pressure filters of 0.5 m.g.d. capacity each and 12 Hyatt pressure filters of 0.25 m.g.d. capacity each, which latter were the original filters installed in 1887.

The basin dimensions given are for the coagulation basin built about 1920. It has sloping sides and hopper shaped bottom. About one-third of the basin at the entrance end is used as a mud basin and may be cleaned independently of the rest of the basin.

4. Baltimore, Md. The supply is impounded on Gunpowder River. The present raw water storage is approximately 23 billion gallons. The coagulation basins are somewhat irregular in shape and have sloping exterior sides. The lime is added to the filtered water to reduce corrosive action.

5. Birmingham, Ala. Lime is used only part time.

Operation figures are for the year 1931.

6. Buffalo, N. Y. Having no mixing chamber, the raw water is dosed with alum at low lift pumps and mixed in 78 feet of conduit to the coagulation basins.

7. Cambridge, Mass. Presedimentation is obtained in impounding and storage reservoirs. Mixing is accomplished in raw water conduit to coagulation basins.

Entrance to coagulation basins is through a wall perforated with 2-inch diameter holes.

Filters are washed to a constant sand expansion which requires variations in rates of wash between the limits given.

The filtered water is aerated.

There is a 48 m.g. filtered water reservoir at Payson Park on the distribution system.

8. Chattanooga, Tenn. Treatment is mostly of alum, but at times some lime is added. Mixing is in 75 feet of raw water conduit and slotted entrance to coagulation basins. The first two coagulation basins have a down baffle at each inlet and skimming weir at each outlet. The three basins are operated in series. The third basin outlet is over 6 fixed skimming funnels.

The filter data given are for the gravity units only. There are also 26 Jewell pressure filters of 0.11 m.g.d. capacity each installed in 1887 and 20 National pressure filters of 0.23 m.g.d. capacity each installed in 1892. The gravity filters were installed in 1913, 1918, 1926, and 1931.

9. Cincinnati, Ohio. This plant has preliminary sedimentation basins of 340 m.g. capacity.

There is no regular mixing chamber, mixing of chemicals with raw water being accomplished in 340 feet of 84-inch conduit to the coagulation basins.

The coagulation basins have sloping sides.

The filters were resanded in 1929, at which time the normal rate of filtration was increased from 125 to 156 m.g.d. per acre.

10. Cleveland, Ohio. At the Division Avenue plant the alum is measured dry by automatic scales dumping given size batches at predetermined intervals into a dissolver from which it is forced by an ejector to the raw water dosing point. Mixing is by a baffled chamber.

At the Baldwin Plant the prepared alum solution is mixed with the raw water by a hydraulic jump followed by a baffled conduit. The time at the jump is very short and the time in the rest of the mixing flume is about one minute. The 600–700 feet per minute velocity given is the velocity in the hydraulic jump. The velocity in baffled conduit is about 300 feet per minute.

11. Columbus, Ohio. The raw water is impounded in a storage reservoir, of about 1.5 billion gallons available capacity, on the Scioto River. This plant is a lime and soda-ash softening plant. Average raw water hardness is 275 p.p.m. Average output hardness 100 p.p.m. The lime mixing tanks are also stirred by mechanical agitators.

The coagulation basin effluent is recarbonated by a pipe grid placed in the bottom of the outlet end of the coagulation basins.

Besides the filtered water storage at the plant there are two 1 m.g. and one 2 m.g. standpipes on the distribution system.

12. Dallas, Texas. The supply is impounded in a 63-billion gallon storage reservoir behind Garza dam and in three other small impounding reservoirs of 0.8 billion gallons combined storage capacity, all on Trinity River.

Filters are washed by direct pump pressure with no wash water tank.

There is a secondary mixing basin of 4 minutes retention period between the settling basins and the filters.

About 80 percent of the water used in Dallas is treated at this plant; about 20 percent is from deep wells and is not treated. The two old filter plants are not now regularly operated.

13. Denver, Colo. There is some presedimentation in impounding Marston Lake on South Platte River. Raw water is aerated by spray nozzles, the water falling into mixing chamber.

Anthracite coal is used as fine filtering material instead of sand.

This is a low head plant, filters being washed at 3½ feet loss-of-head.

14. Detroit, Mich. At the Water Works Park plant chemicals are dosed ahead of raw water pumps and mixed in these pumps followed by a 3 minute baffled chamber at the entrance to the coagulation basins.

At the Springwells plant mixing is by mechanical agitators. The peripheral speed of blades may be varied from ⅔ to 2 feet per second; one foot per second is normal.

There is filtered water storage of about 10 m.g. in six elevated tanks on the distribution system.

15. Erie, Pa. The data given are for the old plant. Data on the new plant, completed in 1931, have not been obtained.

16. Evansville, Ind. The filtered water storage on the distribution system is of 20 m.g. capacity.

17. Flint, Mich.

18. Fort Worth, Texas. There is presedimentation in 15 billion gallon impounding reservoir, Lake Worth, on West Fork of Trinity River.

The inlet to coagulation basins is behind a curtain wall or down baffle and the outlet is over a skimming weir.

19. Grand Rapids, Mich. This plant softens as well as clarifies.

There is a grit basin preceding the mixing chamber.

The five filters added in 1930 are 20 feet 6 inches by 42 feet 0 inches and filter at a lower rate (about 100 m.g.d. per acre).

There is storage on the distribution system of about 9 m.g. capacity.

20. Indianapolis, Ind. The supply is impounded at Broad Ripple on the White River.

The coagulation basins have sloping sides with paved slopes.

Indianapolis also has 36 m.g.d. capacity of slow sand filters and some well water is used.

The effluents from both rapid sand and slow sand filters are combined in a one hour basin before pumping to distribution.

21. Kansas City, Kans. This plant has also two primary basins for preliminary sedimentation before raw water is dosed with chemicals.

The coagulation basins are operated in series and are allowed to

fill up with sediment to within 3 feet of water surface before cleaning, at which depth the time of retention is about 6 hours.

There is filtered water storage of 13 m.g. capacity on the distribution system.

22. Kansas City, Mo. The raw water has preliminary sedimentation in four 200 feet diameter, circular tanks with mechanical clarifiers before being dosed with chemicals.

Mixing is by spiral flow in two 90 feet diameter tangential mixing chambers.

There is storage of 62 m.g. in reservoirs on the distribution system.

23. Knoxville, Tenn. Two circular mixing chambers with mechanical stirrers are operated also with tangential flow at velocities up to 2 feet per second. Water enters tangentially at tops and exits in center of bottoms.

Basin flow is straight through from west to east end. Widths of basin passes vary and basins have sloping sides; the length and width dimensions given are of the average water surface. Basin inlets are behind a fence of wooden slats; outlets are skimming wiers.

The storage on distribution system is 10 m.g. for equalizing and 1 m.g. for reserve.

24. Louisville, Ky. Preliminary sedimentation in two storage reservoirs of 55 m.g. capacity each, or about one day's retention time, precedes dosing of raw water.

There is no regularly designed mixing chamber. Raw water is dosed in a slotted controller and is discharged through a sluice gate into each basin.

The coagulation basins were revamped in 1929. The 6 original filters, built in 1909, were reconstructed in 1931.

A new 30 m.g. filtered water storage reservoir is located about 12 miles from filter plant and acts as an equalizing reservoir on the distribution system. This will be put in service in 1932.

25. Miami, Fla. This is a softening plant.

Mixing tanks are 30 feet in diameter and 22 feet deep. The water travels circumferentially and downward in the 15 minute period with stirring by revolving paddles.

The clarifier basin has mechanical equipment for stirring and frequent sludge removal.

Settled water is recarbonated before filtering. The recarbonation basin has a ½-hour retention period.

There is about 5 m.g. filtered water storage in several elevated tanks on the distribution system.

26. Minneapolis, Minn. At the Columbia Heights plant one of the two old 47 m.g. raw water storage reservoirs was used as a presedimentation basin and the other was covered and used as a filtered water reservoir, flow from which is by gravity to the part of city served.

27. Montreal, Quebec, Canada. The population of Montreal was about 1,100,000 in 1930. This plant (Joseph Street plant) served about 750,000 (in 1931), the balance being served by slow sand filters soon to be abandoned.

Air at a rate of 4 cubic feet per square foot per minute is used for agitating the sand in washing filters. There are 3 reservoirs on distribution system: 1 @ 37 m.g.; 1 @ 60 m.g. and 1 @ 2 m.g. imperial gallons.

28. Nashville, Tenn. The raw water is given a presedimentation period of ½ hour in a grit chamber before dosing.

Lime and iron are dosed, accomplishing some softening.

There is filtered water storage of 50 m.g. capacity on the distribution system.

29. New Orleans, La. Has grit basins for preliminary sedimentation.

Plant extensions are made from year to year as necessary.

Filter underdrain piping in recent filter additions is of seamless brass tubing with the orifices pressed in to catch some impact of the velocity.

30. Norfolk, Va. Each plant has benefit of presedimentation in raw water impounding reservoirs. The Lake Prince reservoir has about 4 billion gallons storage capacity.

The coagulation basins at the Moore's Bridges plant are of irregular width and have sloping sides; the dimensions given are of average water surface.

At the Lake Prince plant the water is aerated by a water fall immediately after mixing in a closed mixing chamber and is discharged from the aerator into the coagulation basins.

31. Oakland, Calif. This supply is impounded on the Mokelumne River.

These two plants supply nine cities which compose the East Bay Municipal Utility District: Richmond, ElCerrito, Albany, Berkeley, Emeryville, Oakland, Alameda, Piedmont and San Leandro. The distribution system is interconnected between the San Pablo plant, located at North Berkeley and the San Leandro plant, located at East Oakland.

The filter underdrains at the San Leandro Plant are of brass tubing.

San Leandro filters are washed one-half section at a time.

32. Oklahoma City, Okla. The supply is impounded in a 5½ billion gallon storage reservoir on the North Canadian River.

The plant consists of primary aerator, primary mixing chamber, coagulation basins, recarbonation at basin outlet, secondary mixing chamber, filters, 1 m.g. clear well, secondary aerator, and 2 m.g. clear well. Plant softens as well as clarifies.

The secondary mixing chamber has 20 minutes retention and uses a rapid mix by 3 motor-driven agitators.

There is an elevated tank of ½ m.g. capacity on the distribution system.

33. Omaha, Nebr. Plant has six large coagulation and settling basins of varying sizes having a total capacity of 80 m.g. Parts of these basins are used for dosing and mixing. Any basin may be drawn from to filters.

34. Passaic Consolidated Water Co.—Little Falls, Plant. This plant supplies Paterson, Bayonne, Passaic, Clifton, and several other New Jersey towns or municipalities.

The plant has no regular mixing chamber, raw water being dosed as it enters the coagulation basins.

The 1902 filters have wash gutters around the walls as well as across the center of the bed.

The 1919 filters have central gutters with front gullet.

There are three reservoirs on distribution system, one each of 150, 30, and 3 m.g. capacity.

35. Philadelphia, Pa. Philadelphia has slow sand filters also in operation.

The coagulation basins at the Belmont rapid sand plant are irregular in shape. Plan dimensions given are of average water surface.

There are three storage reservoirs on distribution system of 600 m.g., 70 m.g., and 40 m.g. capacities.

36. Providence, R. I. There is presedimentation in 37 billion gallon impounding reservoir. The raw water is aerated as it enters plant.

Ferrous sulphate is applied and mixed in raw water conduit 825 feet long at velocity of 15 feet per minute. Hydrated lime is added at a point 270 feet before entrance to the 35 feet diameter mixing tank

which has rotary flow with tangential bottom inlet and tangential top outlet.

The coagulation basins are irregular in shape; dimensions given are averages. The length of travel in both basins is about 4000 feet.

The filtered water is aerated by the available unused filtering head on spray nozzles.

There is no clear water storage at the filter plant. The filtered water storage is on the distribution system: 39 m.g. in Neutaconkanut low service reservoir and 12 m.g. in Longview high service reservoir. These are covered reservoirs.

This rapid sand plant replaced the original slow sand filters at Providence.

37. Richmond, Va. The raw water is polluted by sulfite waste from paper pulp manufacture upstream. The plant has two presedimentation basins of about 85 m.g. capacity each, used singly, giving about 4 days settling period.

Additional mixing of 70 minutes is provided by mixing paddles installed in entrance end of coagulation basins.

Coagulation basins are of somewhat irregular shape; but about the same volume. The dimensions given are averages.

Filter inlets are at the rear of the filters. Filtered water storage at plant by gravity is 3 m.g. but, by pumping, an available storage space of 7.5 m.g. may be used. Filtered water is aerated by pumping through spray nozzles during the nine warmer months of the year.

38. St. Louis, Mo. Chain-of-Rocks Plant: Raw water passes through a grit chamber for presedimentation before dosing. Lime is added at entrance to mixing basin and iron sulphate at exit to mixing basin. The sulphate mixes in the conduit to settling basins. Six settling basins are used in series. The water from these settling basins is dosed with alum at Venturi meters before entering a secondary coagulation chamber where some mixing and coagulation is obtained in a pair of basins, operated in parallel, before being applied to the filters.

The filtered water from the Chain-of-Rocks plant after chlorination flows to Baden and Bissell's Point for storage in 20 m.g. and 54 m.g. reservoirs respectively. Compton Hill reservoir provides 85 m.g. storage on distribution system in the area served by this plant.

Howard Bend Plant: Raw water is pumped to two 150 feet square presedimentation basins, equipped with Dorr clarifiers for 2 hours sedimentation before dosing. Lime is added in a rapid mixing basin

of round-the-end type before entering the four tangential mixing chambers operated in parallel. Iron sulphate is dosed at the entrance to the tangential mixing chambers. The mixed water enters two 150 feet square coagulation basins, equipped with Dorr clarifiers. These basins operate in parallel and have a retention period of 2 hours. From these coagulation basins the water flows to two final sedimentation basins operated in parallel for 8.7 hours final settling. After final settling it passes to a recarbonating basin where, after recarbonation, alum is dosed for secondary coagulation before applying to filters. A 5 m.g. clear well between filters and high pressure pumps provides for flexibility in pumping to the 100 m.g. Stacy Park reservoir on the distribution system for the area supplied by this plant.

39. St. Paul Minn. About 95 percent of supply is from Mississippi River. This is pumped into a chain of 14 small natural lakes partly supplied by springs which also add some to supply. Presedimentation is obtained in these lakes.

Mixing is assisted by compressed air diffused into the water as it enters the mixing chamber. This accomplishes some aeration as well as thorough initial mix of chemicals.

The coagulation basins are normally used in series and the velocity figure is for series operation.

There are two filtered water reservoirs on the distribution system, one of 16 m.g. capacity and one of 18 m.g. capacity.

40. Tampa, Fla. Mixing is by a small bronze impeller set in a 14-inch draft tube in center of the 18 feet and 24 feet square mixing tanks. A 1 H.P. motor drives each impeller.

41. Toledo, Ohio. The original installation in 1910 included 20 filters of 1 m.g. capacity each. In 1913, 14 filters were added and, in 1921, 22 filters were added. The third coagulation basin was added in 1922.

About 3 cubic feet of air per minute per square foot of sand area is used for agitation of sand during washing.

There is 5 m.g. filtered water storage at the filter plant and 16 m.g. at the service pumping station.

42. Toronto, Ontario, Canada. The plant has no regular mixing chamber or coagulation basins but raw water is dosed at pump and is mixed in the pipes conveying it to filters. The filters are "drifting sand" type.

The two main wash water gutters for each filter are in concentric

circles connected radially by six lateral gutters equally spaced. Sand is continually and slowly removed, washed and returned.

Toronto also has slow sand filters. The outputs of the drifting sand filters and slow sand filters are mixed and pumped into the same mains.

Toronto has a 35 m.g. storage reservoir on distribution system.

43. Trenton, N. J. Sudden changes in character of raw water are frequent; for example, turbidity may change from 0 to 1000 p.p.m. in less than one hour.

Filters are located between the coagulation basins and settled water enters filters from the back.

44. Tulsa, Okla. There is some presedimentation in 20 billion gallon impounding Spavinaw Lake and also presedimentation in 500 m.g. Mohawk Lake at plant.

The raw water is aerated by injecting compressed air through Filtros plates in bottom of raw water conduit.

The filter underdrains are of seamless brass tubing with orifices pressed in to catch some impact of velocity.

There is a 10 m.g. filtered water storage reservoir on the distribution system.

45. Washington, D. C. Presedimentation in 100 m.g. Dalecarlia raw water storage reservoir.

Alum is dosed in solution; lime dosed by dry feed. The lime dose is for raising pH of filtered water to prevent corrosion.

There are two mixing chambers which may be operated in series or parallel. Parallel operation data are charted.

The longitudinal, around the end baffles in coagulation basins are slightly oblique to cause a slight reduction in velocity as the water flows through the basins. These basins are operated normally in parallel. The bottoms of basins are sloped to facilitate cleaning.

The filtered water reservoir in filling throttles down the filters.

There are also four other filtered water reservoirs in the distribution system.

There is also a slow sand plant which supplies the low service areas of the city by gravity.

46. Wilmington, Del. The impounded supply serves through two filter plants, one slow sand and one rapid sand type.

Part of raw water supply passes through a 35 m.g. presedimentation reservoir, a 12 m.g. slow sand filter plant and to a 6 m.g. filtered water reservoir. The other part of raw water supply passes through the rapid sand plant.

There is a 40 m.g. filtered water reservoir on the low service distribution system and a 7½ m.g. emergency reservoir on the high service distribution system.

47. Windsor, Ontario, Canada. Two filter units on opposite sides of the operating gallery are operated from the same table. The filter gravel is bonded together with Portland cement grout.

The two mixing chambers are baffled to give decreasing velocities. The length of travel and velocity of mixing given are of the mixing chambers proper. The time of mix includes pumps and conduits preceding these chambers.

48. Youngstown, Ohio. Mixing is accomplished by dosing directly into a 36-inch pipe line, 60 feet long, to coagulation basins. There is a stilling baffle at the entrance to basins. There are four passes from end to end of coagulation basins with a small mixing basin of over-and-under baffles at the entrance to the last pass for secondary coagulation. Length of travel in basins is about 800 feet.

Besides the 1.85 m.g. clear well at the plant there are stand pipes of 3 m.g. capacity on the distribution system.

When the Meander Creek plant is put into operation, in 1932, the operation of the old plant will be discontinued.

The Wheeler Bottoms in the filters of the Meander Creek plant are constructed on a false slab.

The new Youngstown distributing reservoir will have 30 m.g. capacity.

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United States cities of over 100,000 population which do not have rapid sand filtration plants (January, 1932)

City	*Remarks*
Boston, Massachusetts	Impounded Mountain Water Supply
Bridgeport, Connecticut	Surface Supply
Camden, New Jersey	Artesian Wells
Canton, Ohio	Underground Supply
Chicago, Illinois	Lake Michigan Supply
Dayton, Ohio	Well Supply
Des Moines, Iowa	Infiltration Gallery
Duluth, Minnesota	Surface Supply
Elizabeth, New Jersey	Water Furnished by Newark, N. J. Elizabethtown Water Company Cons. and Plainfield Union Water Co.
El Paso, Texas	Deep Well Supply
Fall River, Massachusetts	Surface Supply
Fort Wayne, Indiana	Filter Plant Under Construction
Gary, Indiana	Surface Supply
Hartford, Connecticut	Slow Sand Filters
Houston, Texas	Deep Well Supply
Jacksonville, Florida	Artesian Wells
Jersey City, New Jersey	Surface Supply
Long Beach, California	
Los Angeles, California	Impounded Mountain Water Supply
Lowell, Massachusetts	Slow Sand Filters for Iron Removal
Lynn, Massachusetts	Surface Supply

Memphis, Tennessee	Has Iron Removal Filters Only
Milwaukee, Wisconsin	Lake Michigan Supply
Newark, New Jersey	Impounded Gravity Supply
New Bedford, Massachusetts	Impounded Supply from Protected Water Shed
New Haven, Connecticut	Slow Sand Filters
New York, N. Y.	Impounded Mountain Water Supply
Peoria, Illinois	Underground Supply
Pittsburgh, Pennsylvania	Slow Sand Filters
Portland, Oregon	Surface Supply
Reading, Pennsylvania	Slow Sand Filters
Rochester, New York	
Salt Lake City, Utah	Impounded Mountain Water Supply
San Antonio, Texas	Deep Well Supply
San Francisco, California	Impounded Mountain Water Supply
Seattle, Washington	Impounded Mountain Water Supply
Somerville, Massachusetts	Supplied from Boston Metropolitan Water System
South Bend, Indiana	Artesian Wells
Spokane, Washington	Underground Supply
Springfield, Massachusetts	Impounded Mountain Water Supply
Syracuse, New York	Impounded Gravity Supply
Tacoma, Washington	Mountain Water Supply
Utica, New York	
Waterbury, Connecticut	
Wichita, Kansas	Well Supply
Worcester, Massachusetts	Impounded Supply
Yonkers, New York	Slow Sand Filters

Canadian cities of over 100,000 population which do not have rapid sand filtration plants (January, 1932)

City	*Remarks*
Quebec, Quebec	
Winnipeg, Manitoba	
Ottawa, Ontario	Plant Under Construction

United States cities of over 100,000 population which have rapid sand filtration plants (January, 1932)

Akron, Ohio
Albany, New York
Atlanta, Georgia

Baltimore, Maryland
Birmingham, Alabama
Buffalo, New York

Cambridge, Massachusetts
Chattanooga, Tennessee
Cincinnati, Ohio
Cleveland, Ohio
Columbus, Ohio

Dallas, Texas
Denver, Colorado
Detroit, Michigan

Erie, Pennsylvania
Evansville, Indiana

Flint, Michigan
Fort Worth, Texas

Grand Rapids, Michigan

Indianapolis, Indiana

Kansas City, Kansas
Kansas City, Missouri
Knoxville, Tennessee

Louisville, Kentucky

Miami, Florida
Minneapolis, Minnesota

Nashville, Tennessee
New Orleans, Louisiana
Norfolk, Virginia

Oakland, California
Oklahoma City, Oklahoma
Omaha, Nebraska

Paterson, New Jersey
Philadelphia, Pennsylvania
Providence, Rhode Island

Richmond, Virginia

St. Louis, Missouri
St. Paul, Minnesota
San Diego, California

Tampa, Florida
Toledo, Ohio
Trenton, New Jersey
Tulsa, Oklahoma

Washington, D. C.
Wilmington, Delaware

Youngstown, Ohio

Canadian cities of over 100,000 population which have rapid sand filtration plants (January, 1932)

Montreal, Quebec
Toronto, Ontario
Windsor, Ontario

TEXT OF EMERGENCY RELIEF AND CONSTRUCTION ACT OF 1932—H. R. 9642

An Act to relieved destitution, to broaden the lending powers of the Reconstruction Finance Corporation, and to create employment by providing for and expediting a public-works program.

Be it enacted, etc., That this Act may be cited as the "Emergency Relief and Construction Act of 1932."

TITLE I

RELIEF OF DESTITUTION

Section 1. (a) The Reconstruction Finance Corporation is authorized and empowered to make available out of the funds of the corporation the sum of $300,000,000, under the terms and conditions hereinafter set forth, to the several States and Territories, to be used in furnishing relief and work relief to needy and distressed people and in relieving the hardship resulting from unemployment, but not more than 15 per centum of such sum shall be available to any one State or Territory. Such sum of $300,000,000 shall, until the expiration of two years after the date of enactment of this Act, be available for payment to the governors of the several States and Territories for the purposes of this section, upon application therefor by them in accordance with subsection (c), and upon approval of such applications by the corporation.

(b) All amounts paid under this section shall bear interest at the rate of 3 per centum per annum, and, except in the case of Puerto Rico and the Territory of Alaska, shall be reimbursed to the corporation, with interest thereon at the rate of 3 per centum per annum, by making annual deductions, beginning with the fiscal year 1935, from regular apportionments made from future Federal authorizations in aid of the States and Territories for the construction of highways and rural post roads, of an amount equal to one-fifth of the share which such State or Territory would be entitled to receive under such apportionment, except for the provisions of this section, or of an amount equal to one-fifth of the amounts so paid to the governor

of such State or Territory pursuant to this section and all accrued interest thereon to the date of such deduction, whichever is the lesser, until the sum of such deductions equals the total amounts paid under this section and all accrued interest thereon. Whenever any such deduction is made, the Secretary of the Treasury shall immediately pay to the corporation an amount equal to the amount so deducted. If any State or Territory shall, within two years after the date of enactment of this Act, enter into an agreement with the corporation for the repayment to the corporation of the amounts paid under this section to the governor of such State or Territory, with interest thereon as herein provided, in such installments and upon such terms as may be agreed upon, then the deduction under this subsection shall not be made unless such State or Territory shall be in default in the performance of the terms of such agreement. In the case of a default by the State or Territory in any such agreement, the agreement shall thereupon be terminated and reimbursement of the unpaid balance of the amount covered by such agreement shall be made by making annual deductions in the manner above provided (beginning with the fiscal year next following such default) from regular apportionments made to such State or Territory from future Federal authorizations in aid of the States and Territories for the construction of highways and rural post roads. Before any amount is paid under this section to the Governor of Puerto Rico or of the Territory of Alaska, Puerto Rico or the Territory of Alaska shall enter into an agreement with the corporation for the repayment of such amount with interest thereon as herein provided, in such installments and upon such terms and conditions as may be agreed upon.

(c) The governor of any State or Territory may from time to time make application for funds under this section, and in each application so made shall certify the necessity for such funds and that the resources of the State or Territory, including moneys then available and which can be made available by the State or Territory, its political subdivisions, and private contributions, are inadequate to meet its relief needs. All amounts paid to the governor of a State or Territory under this section shall be administered by the governor, or under his direction, and upon his responsibility. The governor shall file with the corporation and with the auditor of the State or Territory (or, if there is no auditor, then with the official exercising comparable authority) a statement of the disbursement made by him under this section.

(d) Nothing in this section shall be construed to authorize the corporation to deny an otherwise acceptable application under this section because of constitutional or other legal inhibitions or because the State or Territory has borrowed to the full extent authorized by law. Whenever an application under this section is approved by the corporation in whole or in part, the amount approved shall be immediately paid to the governor of the State or Territory upon delivery by him to the corporation of a receipt therefor stating that the payment is accepted subject to the terms of this section.

(e) Any portion of the amount approved by the corporation for payment to the governor of a State or Territory shall, at his request, and with the approval of the corporation, be paid to any municipality or political subdivision of such State or Territory if (1) the governor makes as to such municipality or political subdivision a like certificate as provided in subsection (c) as to the State or Territory, and (2) such municipality or political subdivision enters into an agreement with the corporation for the repayment to the corporation of the amount so paid with interest at the rate of 3 per centum per annum at such times and upon such other terms and conditions as may be agreed upon between the corporation and such municipality or political subdivision. The amount paid to any municipality or political subdivision under this subsection shall not be included in any amounts reimbursable to the corporation under subsection (b) of this section.

(f) As used in this section the term "Territory" means Alaska, Hawaii, and Puerto Rico.

TITLE II

LOANS BY RECONSTRUCTION FINANCE CORPORATION

Sec. 201. (a) The Reconstruction Finance Corporation is authorized and empowered—

(1) To make loans to or contracts with, States, municipalities, and political subdivisions of States, public agencies of States, of municipalities, and of political subdivisions of States, public corporations, boards and commissions, and public municipal instrumentalities of one or more States, to aid in financing projects authorized under Federal, State, or municipal law which are self-liquidating in character, such loans or contracts to be made through the purchase of their securities, or otherwise, and for such purpose the Reconstruction Finance Corporation is authorized to bid for such securities:

Provided, That nothing herein contained shall be construed to prohibit the Reconstruction Finance Corporation, in carrying out the provisions of this paragraph, from purchasing securities having a maturity of more than ten years;

(2) to make loans to corporations formed wholly for the purpose of providing housing for families of low income, or for reconstruction of slum areas, which are regulated by State or municipal law as to rents, charges, capital structure, rate of return, and areas and methods of operation, to aid in financing projects undertaken by such corporations which are self-liquidating in character;

(3) to make loans to private corporations to aid in carrying out the construction, replacement or improvement of bridges, tunnels, docks, viaducts, waterworks, canals, and markets, devoted to public use and which are self-liquidating in character.

(4) to make loans to private limited dividend corporations to aid in financing projects for the protection and development of forests and other renewable natural resources, which are regulated by a State or political subdivision of a State and are self-liquidating in character; and

(5) to make loans to aid in financing the construction of any publicly owned bridge to be used for railroad, railway, and highway uses, the construction cost of which will be returned in part by means of tolls, fees, rents, or other charges and the remainder by means of taxes imposed pursuant to State law enacted before the date of enactment of the Emergency Relief and Construction Act of 1932; and the Reconstruction Finance Corporation is further authorized and empowered to purchase bonds of any State, municipality, or other public body or agency issued for the purpose of financing the construction of any such bridge irrespective of the dates of maturity of such bonds.

For the purposes of this subsection a project shall be deemed to be self-liquidating if such project will be made self-supporting and financially solvent and if the construction cost thereof will be returned within a reasonable period by means of tolls, fees, rents, or other charges, or by such other means (other than by taxation) as may be prescribed by the statutes which provide for the project.

All loans and contracts made by the Reconstruction Finance Corporation in respect of projects of the character specified in paragraphs

(1) to (5) of this subsection shall be subject to the conditions that no convict labor shall be directly employed on any such project, and that (except in executive, administrative and supervisory positions), so far as practicable, no individual directly employed on any such project shall be permitted to work more than thirty hours in any one week, and that in the employment of labor in connection with any such project preference shall be given, where they are qualified, to ex-service men with dependents.

The provisions of this subsection shall apply with respect to projects in Puerto Rico and the Territories to the same extent as in the case of projects in the several States, and as used in this subsection the term "States" includes Puerto Rico and the Territories.

(b) The Reconstruction Finance Corporation shall submit monthly to the President and to the Senate and the House of Representatives (or the Secretary of the Senate and the Clerk of the House of Representatives, if those bodies are not in session) a report of its activities and expenditures under this section and under the Reconstruction Finance Corporation Act, together with a statement showing the names of the borrowers to whom loans and advances were made, and the amount and rate of interest involved in each case.

(c) In order that the surpluses of agricultural products may not have a depressing effect upon current prices of such products, the corporation is authorized and directed to make loans, in such amounts as may in its judgment be necessary, for the purpose of financing sales of such surpluses in the markets of foreign countries in which such sales can not be financed in the normal course of commerce; but no such sales shall be financed by the corporation if, in its judgment, such sales will affect adversely the world markets for such products. *Provided, however,* That no such loan shall be made to finance the sale in the markets of foreign countries of cotton owned by the Federal Farm Board or the Cotton Stabilization Corporation.

(d) The Reconstruction Finance Corporation is authorized and empowered to make loans to bona fide institutions, organized under the laws of any State or of the United States and having resources adequate for their undertaking, for the purpose of enabling them to finance the carrying and orderly marketing of agricultural commodities and livestock produced in the United States.

(e) The Reconstruction Finance Corporation is further authorized to create in any of the twelve Federal land-bank districts where it may

deem the same to be desirable a regional agricultural credit corporation with a paid-up capital of not less than $3,000,000, to be subscribed for by the Reconstruction Finance Corporation and paid for out of the unexpended balance of the amounts allocated and made available to the Secretary of Agriculture under section 2 of the Reconstruction Finance Corporation Act.

Such corporations shall be managed by officers and agents to be appointed by the Reconstruction Finance Corporation under such rules and regulations as its board of directors may prescribe. Such corporations are hereby authorized and empowered to make loans or advances to farmers and stockmen, the proceeds of which are to be used for an agricultural purpose (including crop production), or for the raising, breeding, fattening, or marketing of livestock, to charge such rates of interest or discount thereon as in their judgment are fair and equitable, subject to the approval of the Reconstruction Finance Corporation, and to rediscount with the Reconstruction Finance Corporation and the various Federal reserve banks and Federal intermediate credit banks any paper that they acquire which is eligible for such purpose.

All expenses incurred in connection with the operation of such corporations shall be supervised and paid by the Reconstruction Finance Corporation under such rules and regulations as its board of directors may prescribe.

(f) All loans made under this section, and all contracts of the character described in paragraph (1) of subsection (a), shall be fully and adequately secured. The corporation, under such conditions as it shall prescribe, may take over or provide for the administration and liquidation of any collateral accepted by it as security for such loans. Such loans shall be made on such terms and conditions, not inconsistent with this Act, as the corporation may prescribe, and may be made directly upon promissory notes or by way of discount or rediscount of obligations tendered for the purpose, or otherwise in such form and in such amount and at such interest or discount rates as the corporation may approve: *Provided*, That no loans or advances (except loans under subsection (c)) shall be made upon foreign securities or foreign acceptances as collateral.

(g) Each such loan may be made for a period not exceeding three years, and the corporation may, from time to time, extend the time of payment of any such loan through renewal, substitution of new

obligations, or otherwise, but the time for such payment shall not be extended beyond five years from the date upon which such loan was made originally: *Provided*, That loans or contracts of the character described in subsection (a) may be made for a period not exceeding ten years: *Provided further*, That loans or contracts of the character described in paragraph (1) or (5) of subsection (a) may be made for a period exceeding ten years when it is the judgment of the board of directors of the corporation that it is necessary to purchase securities as provided in such paragraphs and that it is not practicable to require the reimbursement of the corporation, within ten years, through the repurchase or payment of such securities, or in any other manner.

(h) The corporation may make loans under this section at any time prior to January 23, 1934.

(i) No fee or commission shall be paid by any applicant for a loan under the provisions of this section in connection with any such application or any loan made or to be made under this section, and the agreement to pay or payment of any such fee or commission shall be unlawful.

(j) No loan under this section shall be made to a railroad or to a receiver of a railroad except on the approval of the Interstate Commerce Commission. Any railroad may obligate itself in such form as shall be prescribed and otherwise comply with the requirements of the Interstate Commerce Commission and the corporation with respect to the deposit or assignment of security hereunder, without the authorization or approval of any authority, State or Federal, and without compliance with any requirement, State or Federal, as to notification, other than such as may be imposed by the Interstate Commerce Commission and the corporation under the provisions of this section.

Sec. 202. The last sentence of the second paragraph of section 5 of the Reconstruction Finance Corporation Act is amended by striking out "5" and inserting "$2\frac{5}{8}$" in lieu thereof.

Sec. 203. The second sentence of the third paragraph of section 5 of the Reconstruction Finance Corporation Act is hereby repealed.

Sec. 204. Section 8 of the Reconstruction Finance Corporation Act is amended to read as follows:

"*Sec. 8.* In order to enable the corporation to carry out the provisions of this Act and the Emergency Relief and Construction Act of 1932, the Treasury Department, the Federal Farm Loan Board, the Comptroller of the Currency, the Federal Reserve Board, the Federal reserve banks, and the Interstate Commerce Commission are hereby authorized, under such conditions as they may prescribe, to make available to the corporation, in confidence, such reports, records, or other information as they may have available relating to the condition of applicants with respect to whom the corporation has had or contemplates having transactions under either of such Acts, or relating to individuals, associations, partnerships, corporations, or other obligors whose obligations are offered to or held by the corporation as security for loans under either of such Acts, and to make, through their examiners or other employes for the confidential use of the corporation, examinations of applicants for loans. Every applicant for a loan under either of such Acts shall, as a condition precedent thereto, consent to such examination as the corporation may require for the purposes of either of such Acts and that reports of examinations by constituted authorities may be furnished by such authorities to the corporation upon request therefor."

Sec. 205. (a) The amount of notes, debentures, bonds, or other such obligations which the Reconstruction Finance Corporation is authorized and empowered under section 9 of the Reconstruction Finance Corporation Act to have outstanding at any one time is increased to an aggregate of six and three-fifths times its subscribed capital stock.

(b) The first proviso of section 2 of the Reconstruction Finance Corporation Act is amended by inserting after "as set out in section 9" the following: "(as in force prior to the enactment of the Emergency Relief and Construction Act of 1932)," but the Secretary of Agriculture is directed to continue making loans to farmers under the provisions of such section 2.

Sec. 206. The Reconstruction Finance Corporation is authorized and empowered to make loans under the Reconstruction Finance Corporation Act to financial institutions, corporations, railroads, and other classes of borrowers specified in section 5 of such Act, organized under the laws of the District of Columbia, Alaska, Hawaii, and Puerto Rico. As used in this title and in section 15 of the Recon-

struction Finance Corporation Act the term "State" includes the District of Columbia, Alaska, Hawaii, and Puerto Rico.

Sec. 207. No loan or advance shall be approved under this section or under the Reconstruction Finance Corporation Act, directly or indirectly, to any financial institution any officer or director of which is a member of the board of directors of the Reconstruction Finance Corporation or has been such a member within the twelve months preceding the approval of the loan or advance.

Sec. 208. The first sentence of section 3 of the Reconstruction Finance Corporation Act is amended, effective at the expiration of ten days after the date of enactment of this Act, to read as follows: "The management of the corporation shall be vested in a board of directors consisting of the Secretary of the Treasury (or, in his absence, the Under Secretary of the Treasury); who shall be a member ex officio, and six other persons appointed by the President of the United States by and with the advice and consent of the Senate."

(b) Nothing in this section shall be construed to affect in any manner the terms of office of the appointed members of the board of directors of the Reconstruction Finance Corporation, nor to require their reappointment.

Sec. 209. Section 9 of the Reconstruction Finance Corporation Act is hereby amended by adding at the end thereof the following:

"The Secretary of the Treasury, at the request of the Reconstruction Finance Corporation, is authorized to market for the corporation its notes, debentures, bonds, and other such obligations, using therefor all the facilities of the Treasury Department now authorized by law for the marketing of obligations of the United States. The proceeds of the obligations of the corporation so marketed shall be deposited in the same manner as proceeds derived from the sale of obligations of the United States, and the amount thereof shall be credited to the corporation on the books of the Treasury."

Sec. 210. Section 13 of the Federal Reserve Act, as amended, is further amended by adding after the second paragraph thereof the following new paragraph:

"In unusual and exigent circumstances, the Federal Reserve Board, by the affirmative vote of not less than five members, may authorize any Federal reserve bank, during such periods as the said board may determine, at rates established in accordance with the provisions of section 14, subdivision (d), of this Act, to discount for any individual, partnership, or corporation notes, drafts, and bills

of exchange of the kinds and maturities made eligible for discount for member banks under other provisions of this Act when such notes, drafts, and bills of exchange are indorsed and otherwise secured to the satisfaction of the Federal reserve bank: *Provided*, That before discounting any such note, draft, or bill of exchange for an individual, partnership, or corporation the Federal reserve bank shall obtain evidence that such individual, partnership or corporation is unable to secure adequate credit accommodations from other banking institutions. All such discounts for individuals, partnerships or corporations shall be subject to such limitations, restrictions, and regulations as the Federal Reserve Board may prescribe."

Sec. 211. The first paragraph of section 5 of the Reconstruction Finance Corporation Act is hereby amended to read as follows:

"*Sec. 5.* To aid in financing agriculture, commerce, and industry, including facilitating the exportation of agricultural and other products the corporation is authorized and empowered to make loans, upon such terms and conditions not inconsistent with this Act as it may determine, to any bank, savings bank, trust company, building and loan association, insurance company, mortgage loan company, credit union, Federal land bank, joint-stock land bank, Federal intermediate credit bank, agricultural credit corporation, livestock credit corporation, organized under the laws of any State or of the Unites States, including loans secured by the assets of any bank or savings bank that is closed, or in process of liquidation to aid in the reorganization or liquidation of such banks, upon application of the receiver or liquidating agent of such bank and any receiver of any national bank is hereby authorized to contract for such loans and to pledge any assets of the bank for securing the same: *Provided*, That not more than $200,000,000 shall be used for the relief of banks that are closed or in the process of liquidation."

TITLE III

PUBLIC WORKS

Sec. 301. (a) For the purpose of providing for emergency construction of certain authorized public works with a view to increasing employment and carrying out the policy declared in the Employment Stabilization Act of 1931, there is hereby appropriated, out of any money in the Treasury not otherwise appropriated, the sum of $322,224,000, which shall be allocated as follows:

(1) For expenditure in emergency construction on the Federal-aid highway system, $120,000,000. Such sum shall be apportioned by the Secretary of Agriculture to the several States by the method provided in section 21 of the Federal Highway Act, as amended and supplemented (U. S. C., title 23, sec. 21). The amounts apportioned to the States shall be available as a temporary advance of funds to meet the provisions of such Act as to State funds. The amount apportioned to any State under this paragraph may be used to match the regular annual Federal-aid apportionments made to such State (including the one for the fiscal year ending June 30, 1933) and when so used such amount shall be available for expenditure in paying the share of such State in the cost of Federal-aid projects. No amounts apportioned under this paragraph shall be advanced except for work on the Federal-aid highway system performed before July 1, 1933:

Provided, That the amounts so advanced shall be reimbursed to the Federal Government over a period of ten years, commencing with the fiscal year 1938, by making annual deductions from regular apportionments made from future authorizations for carrying out the provisions of such Act, as amended and supplemented:

Provided further, That all contracts involving the expenditure of such amounts shall contain provisions establishing minimum rates of wages, to be predetermined by the State highway department, which contractors shall pay to skilled and unskilled labor, and such minimum rates shall be stated in the invitation for bids and shall be included in proposals or bids for the work: *And provided further*, That in the expenditure of such amounts, the limitations in the Federal Highway Act as amended and supplemented, upon highway construction, reconstruction, and bridges within municipalities and upon payments per mile which may be made from Federal funds, shall not apply. As used in this paragraph, the term "State" includes the Territory of Hawaii.

The term "highway," as defined in the Federal Highway Act, approved November 9, 1921, as amended and supplemented, for the purposes of this paragraph only, shall be deemed to include such main State parkways as may be designated by the State and approved by the Secretary of Agriculture as part of the Federal-aid highway system.

(2) For expenditure in emergency construction during the fiscal year ending June 30, 1933, $16,000,000 as follows:

(A) For the construction and improvement of national-forest highways, $5,000,000;

(B) For the construction and maintenance of roads, trails, bridges, fire lanes, and so forth, including the same objects specified in the paragraph commencing with the words "Improvements of the national forests" under the heading "National Forest Administration" in the Agricultural Appropriation Act for the fiscal year ending June 30, 1932, approved February 23, 1931 (46 Stat. 1242), $5,000,000;

(C) For the construction, reconstruction, and improvement of roads and trails, inclusive of necessary bridges, in the national parks and national monuments under the jurisdiction of the Department of the Interior including areas to be established as national parks authorized under the Act of May 22, 1926 (U. S. C., Supp. V, title 16, secs. 403 to 403c), and under the Act of May 25, 1926 (U. S. C., Supp. V, title 16, secs. 404 to 404c), and national park and monument approach roads authorized by the Act of January 31, 1931 (46 Stat. 1053), as amended, or any one section of such roads of not less than eight miles, which crosses lands wholly or to the extent of 90 percent owned by the Government of the United States, $3,000,000;

(D) For construction and improvement of Indian reservation roads under the provisions of the Act approved May 26, 1928 (U. S. C., Supp. V, title 25, sec. 318a), $1,000,000; and

(E) For the survey construction, reconstruction, and maintenance of main roads through unappropriated or unreserved public lands, nontaxable Indian lands, or other Federal reservations other than the forest reservations, under the provisions of section 3 of the Federal Highway Act, as amended and supplemented (U. S. C., Supp. V, title 23, secs. 3 and 3a), $2,000,000. The Secretary of Agriculture and the Secretary of the Interior respectively, are authorized to make rules and regulations for carrying out the foregoing provisions of this section with a view to providing the maximum employment of local labor consistent with reasonable economy of construction.

(3) For the prosecution of river and harbor projects heretofore authorized, $30,000,000.

(4) For the prosecution of flood-control projects heretofore authorized, $15,500,000.

(5) For the continuation of construction of the Hoover Dam and incidental works, as authorized by the Boulder Canyon Project Act, approved December 21, 1928 (U. S. C., Supp. V, title 43, ch. 12A), $10,000,000.

(6) For expenditure by the Department of Commerce for air-navigation facilities, including equipment, $500,000.

(7) For constructing or purchasing and equipping lighthouse tenders and light vessels for the Lighthouse Service as may be specifically approved by the Secretary of Commerce, $950,000, and for establishing and improving aids to navigation and other works as may be specifically approved by the Secretary of Commerce, $2,860,000.

(8) For the engineering work of the Coast and Geodetic Survey, Department of Commerce, heretofore authorized, $1,250,000.

(9) For the construction of projects included in the report of the Federal Employment Stabilization Board, laid before the Senate January 25, 1932, which have heretofore been authorized or which do not require specific authorization, under the Bureau of Yards and Docks, Navy Department, $10,000,000, of which not to exceed $300,000 shall be available for the employment of classified personal services in the Bureau of Yards and Docks and in the field service to be engaged upon such work and to be in addition to employees otherwise provided for.

(10) For emergency construction of public building projects outside the District of Columbia (including the acquisition, where necessary, by purchase, condemnation, or otherwise, of sites and additional land for such buildings, the demolition of old buildings were necessary, and the construction, remodeling, or extension of buildings), such projects to be selected by the Secretary of the Treasury and the Postmaster General from the public building projects specified in House Document Numbered 788, Seventy-first Congress, third session, $100,000,000. Such projects shall be carried out within the limits of cost specified in such document (except as modified by law), and in selecting such projects preference shall be given to places where Government facilities are housed in rented buildings under leases which will expire on or before July 1, 1934, or which may be terminated on or prior to that date by the Government.

(11) For the construction and installation at military posts of such buildings and utilities and appurtenances thereto as may be necessary, $15,164,000, as follows:

Albrook Field, Canal Zone: Quartermaster maintenance building, $20,000; post exchange, theater, and gymnasium, completion of, $42,000.

Barksdale Field, Louisiana: Noncommissioned officers' quarters, $262,00; officers' quarters, $609,000; barracks, $474,000; hospital, completion of, $225,000; garage, completion of, $30,000; quartermaster warehouse, completion of, $15,000.

William Beaumont General Hospital, Texas: Noncommissioned officers' quarters, $7,000; warehouse, $15,000.

Fort Benning, Georgia: Barracks, $650,000.

Fort Bliss, Texas: Noncommissioned officers' quarters, $50,000; officers' quarters, $150,000.

Bolling Field, District of Columbia: Noncommissioned officers' quarters, $54,000; dispensary, completion of, $30,000; post exchange, theater, and gymnasium, completion of, $45,000; officers' mess, $500,000; enlargement of central heating plant to provide for quarters area, $95,000.

Fort Bragg, North Carolina: Barracks, completion of, $40,000; noncommissioned officers' quarters, $160,000.

Carlisle Barracks, Pennsylvania: Heating plant, $200,000.

Chanute Field, Illinois: Noncommissioned officers' quarters, $137,000; central heating plant for technical and quarters area, $200,000.

Camp Devens, Massachusetts: Roads and sidewalks, $75,000; service club, $30,000; post exchange and gymnasium, $50,000.

Fort Douglas, Utah: Noncommissioned officers' quarters, $15,000.

Dryden, Texas: Barracks, $20,000.

Duncan Field, Texas: Quartermaster warehouse, $40,000; quartermaster maintenance building, $20,000; garage, $40,000; fire and guard house, $25,000.

Fort Du Pont, Delaware: Noncommissioned officers' quarters, $60,000.

Edgewood Arsenal, Maryland: Noncommissioned officers' quarters, $70,000.

Fitzsimons General Hospital, Colorado: Gymnasium, recreation, and social hall, $150,000.

Hamilton Field, California: Officers' quarters, $215,000; noncommissioned officers' quarters, $120,000.

Fort Hamilton, New York: Noncommissioned officers' quarters, $100,000.

Fort Benjamin Harrison, Indiana: Noncommissioned officers' quarters, $120,000.

Hensley Field, Texas: Noncommissioned officers' quarters, $8,000; officers' quarters, $30,000; roads, utilities, and improvement of flying field, $25,000; replacement of pumping plant, $3,000; sewage-disposal plant, $3,000.

Holabird Quartermaster Depot, Maryland: Hospital, $120,000.

Fort Sam Houston, Texas: Noncommissioned officers' quarters, $150,000; officers' quarters, $350,000.

Fort Howard, Maryland: Hospital, $150,000.

Fort Hoyle, Maryland: Noncommissioned officers' quarters, $70,000.

Fort Humphreys, Virginia: Officers' quarters, $150,000.

Fort Huachuca, Arizona: Post exchange, gymnasium, and service club, $100,000.

Fort Jay, New York: Noncommissioned officers' quarters, $130,000, barracks, completion of, $70,000; officers' quarters, $125,000; nurses' quarters, completion of, $35,000.

Jefferson Barracks, Missouri: Noncommissioned officers' quarters, $65,000; additions to kitchens and mess halls, $55,000.

Camp Knox, Kentucky: Hospital, $200,000.

Langley Field, Virginia: Cental heating plant for quarters area, $60,000; quartermaster maintenance building, $20,000; fire house, $20,000; barracks, medical detachment, $30,000; garage, completion of, $15,000; magazine, completion of, $10,000.

Fort Lawton, Washington: Noncommissioned officers' quarters, $30,000.

Fort Leavenworth, Kansas: Nurses' quarters, $60,000.

Letterman General Hospital, California: Two wards, $150,000.

Fort Lewis, Washington: Barracks, completion of, $30,000; water main, $30,000; noncommissioned officers' quarters, $75,000; officers' quarters, $65,000.

Fort Logan, Colorado: Noncommissioned officers' quarters, $53,000.

Fort McClellan, Alabama: Headquarters, $50,000; recreation hall, $35,000; gymnasium, $45,000.

Fort McPherson, Georgia: Nurses' quarters, $70,000; contagious ward for hospital, $70,000.

Maxwell Field, Alabama: Officers' quarters, $940,000; officers' mess, $55,000.

March Field, California: Barracks for medical detachment, $25,000; contagious ward for hospital, $12,000; bakery, $15,000; laundry, $60,000; enlisted men's service club, $50,000; officers' mess, $50,000; theater, $40,000.

Fort Mason, California: Officers' quarters, $110,000.

Fort Meade, South Dakota: Riding hall, $25,000.

Fort George G. Meade, Maryland: Noncommisioned officers' quarters, $150,000; officers' quarters, $50,000.

Mitchel Field, New York: Noncommissioned officers' quarters, $118,000; bakery, $15,000; incinerator, $10,000; enlisted men's service club, $50,000; theater, $40,000; sewage-disposal plant, $40,000; fence, $31,000; quartermaster gasoline storage, $3,000; magazine, $15,000; officers' mess, $50,000; coal storage and handling system, $70,000; roads, walks, and surface-drainage system, $86,000.

Fort Monmouth, New Jersey: Addition to hospital, $75,000; noncommissioned officers' quarters, $170,000; band barracks, $35,000.

Fort Myer, Virginia: Barracks, $100,000.

Fort Oglethorpe, Georgia: Noncommissioned officers' quarters, $120,000.

Fort Ontario, New York: Noncommissioned officers' quarters, $50,000.

Plattsburg Barracks, New York: Additions to barracks, $25,000; barracks, $255,000.

Pope Field, North Carolina, for the Air Corps troops: Barracks, $140,000; noncommissioned officers' quarters, $84,000; officers' quarters, $140,000.

Post Field, Oklahoma, for Air Corps troops: Barracks, $140,000; noncommissioned officers' quarters, $84,000; officers' quarters, $140,000.

Presidio of San Francisco, California: Noncommissioned officers' quarters, $60,000; addition to headquarters, $50,000.

Randolph Field, Texas: Barracks, completion of, $56,000; gymnasium, completion of, $70,000; roads and utilities, $243,000; completion of chapel and school, $50,000.

Raritan Arsenal, New Jersey: Noncommissioned officers' quarters, $75,000.

Walter Reed General Hospital, District of Columbia: Noncommissioned officers' quarters, $120,000; addition to nurses' quarters, $300,000.

Rock Island Arsenal, Illinois: Noncommissioned officers' quarters, $15,000.

Rockwell Field, California: Noncommissioned officers' quarters, $234,000; officers' quarters, $266,000.

Fort Winfield Scott, California: Noncommissioned officers' quarters, $140,000.

Selfridge Field, Michigan: Gymnasium and theater, $80,000; garage, $40,000; quartermaster maintenance building, $20,000; post exchange, $45,000; officers' mess, $60,000; enlisted men's service club, $50,000; bakery, $15,000; roads and utilities, $75,000.

Fort Sill, Oklahoma: Barracks, $875,000; noncommissioned officers' quarters, $72,000; officers' quarters, $75,000; gun sheds, $48,000; stables, $30,000; vehicle shed, $10,000.

Fort Snelling, Minnesota: Quartermaster warehouse, $65,000; barracks, medical detachment, $40,000.

Fort Totten, New York: Noncommissioned officers' quarters, $30,000.

Fort Wadsworth, New York: Officers' quarters, $75,000.

Fort Francis E. Warren, Wyoming: Noncommissioned officers' quarters, $120,000.

West Point, New York: For addition to hospital, $250,000; barracks for service detachment, $250,000.

Fort George Wright, Washington: Noncommissioned officers' quarters, $60,000.

(b) No part of the sum appropriated by this section, except the amount for expenditure under paragraph (1) or (2) of subsection (a), shall be expended if the Secretary of the Treasury certifies to the President that the amount necessary for such expenditure is not available and can not be obtained upon reasonable terms.

Sec. 302. There is hereby authorized to be appropriated not to exceed $7,436,000, to be expended for the construction and installation at military posts, and at airports and landing fields, of such technical buildings and utilities and appurtenances thereto as may be necessary, as follows:

Albrook Field, Canal Zone: Technical buildings and installations, completion of, $293,000; gasoline-storage system, completion of, $25,000.

Barksdale Field, Louisiana: Hangars, $350,000; headquarters and operations buildings, completion of, $89,200; gasoline-storage system, completion of, $20,000; paved aprons, $100,000.

Fort Benning, Georgia: Hangar, combination, $88,000; gasoline-storage system, $10,000; improvement of landing field and building area, $25,000; heating plant, $20,000; paved aprons, $20,000.

Benton Field, Alameda, California: Completion of shops, including assembly and test hangars, dope storage, heating and engine test block, $605,500; depot warehouse, $500,000; administration building, $80,000; railroad spur, $8,000; quartermaster warehouse, maintenance and salvage building, $35,000; garage, $48,000; fire and guard house, $30,000; pier, $125,000; paint, oil, and dope storage and oil reclamation, $35,000; gasoline-storage system, $20,000; paved aprons, $80,000.

Fort Bliss, Texas: Operations building, $10,000.

Bolling Field, District of Columbia: Paved aprons, completion of, $22,800; heating plant for technical area, completion of, $78,000; field shops, completion of, $6,000; improvement of landing field and building area, $615,000.

Chanute Field, Illinois: Hangars, $170,000; paved aprons, $30,000; improvement of landing field and technical area, $15,000; enlargement of central heating plant and steam lines, $185,000.

Dryden, Texas: Paved aprons and hangar floor, $15,000.

Duncan Field, Texas: Depot administration building, $60,000; gasoline-storage system, completion of, $15,000.

Hatbox Field, Muskogee, Oklahoma: Roofing sidewalls for hangar, and paved aprons, $15,000.

Hamilton Field, California: Headquarters and operations building, to complete, $35,000; improvement of landing field and building area, $120,000.

Langley Field, Virginia: Remodeling two hangars into shops, and for ceilings in and additions to hangars, $91,000; gasoline-storage system, completion of, $21,000; bomb storage, $19,000; improvement of landing field and building area, $25,000; machine-gun range, $6,000.

Luke Field, Hawaiian Department: Air depot, plane overhaul and assembly, $200,000.

March Field, California: Gasoline-storage system, completion of, $10,000; aircraft-bomb storage, $5,000.

Maxwell Field, Alabama: Squadron officers' school and/or additions to school building, $150,000; gasoline-storage system, $10,200; improvement of landing field, $100,000; camera obscura, $4.000; bomb storage, $13,000; machine-gun and bombing range, $6,000.

Mitchel Field, New York: Improvement of landing field, $80,000; gasoline-storage system, completion of, $5,000; bomb storage, $13,000; machine-gun range, $2,000.

Panama Canal Zone: Improvement of emergency landing fields at Gamboa Reach and Camp Gaillard, $20,000.

Patterson Field, Ohio: Hangars, headquarters and operations, and heating plant, completion of, $251,300; improvement of landing field and building area, $5,000; gasoline-storage system, completion of, $10,000.

Pope Field, North Carolina: Hangar—balloon-dismantle, transfer, and reërection of, $110,000; paved aprons, $15,000; paint, oil, and dope storage, $5,000.

Post Field, Oklahoma: Hangar—balloon-dismantle, transfer, and reërection of, $110,000; paved aprons, $15,000.

Randolph Field, Texas: Engine-test stands and building, $40,000; oil storage, $15,000; gasoline-storage system, completion of, $10,000; aerial target range, $20,000.

Rockwell Field, California: Hangars, $576,000; Air Corps warehouse, $80,000; operations building, $20,000; remodeling a permanent building for radio, parachute, and armament building, $20,000; administration building, $80,000; photographic bu'lding, $36,000; paint, oil, and dope storage, $15,000; gasoline-storage system, $30,000; paved aprons, $95,000; central heating plants, $100,000; improvement of landing field and technical building area, $100,000; camera obscura, $5,000; bomb storage, $15,000.

Schoen Field, Indiana: Grading landing field, $5,000.

Scott Field, Illinois: Hangar, $90,000; headquarters and operations buildings, $80,000; barracks, $271,000; radio building, $10,000; photo building, $36,000; gas plant and chemical storage, $50,000; central heating plants, $145,000; gasoline-storage system, $10,000; paved aprons, $40,000; improvement of landing field and building area, $50,000; machine-gun buts, $3,000.

Selfridge Field, Michigan: Gasoline-storage system, completion of, $10,000.

Wheeler Field, Hawaiian Department: Gasoline-storage system, completion of, $31,000; paved aprons, $38,000.

Sec. 303. No money shall be available for expenditure under this title in connection with a project in the District of Columbia, except as provided in section 301 (a) (11) or 302.

Sec. 304. The last paragraph of section 6 of the Federal Highway Act, approved November 9, 1921, as amended and supplemented (U. S. C., title 23, sec. 6), is hereby amended to read as follows:

"Whenever provision has been made by any State for the completion and maintenance of 90 per centum of its system of primary or interstate and secondary or intercounty highways equal to 7 per centum of the total mileage of such State, as required by this Act, said State through its State highway department, by and with the approval of the Secretary of Agriculture, is hereby authorized to increase the mileage of the primary or interstate and secondary or intercounty systems by additional mileage equal to not more than 1 per centum of said total mileage of such State and thereafter to make like increases in the mileage of said systems whenever provision has been made for the completion and maintenance of 90 per centum of the mileage of said systems previously authorized in accordance herewith."

Sec. 305. After the date of the enactment of this Act, in the acquisition of any land or site for the purposes of section 301 (a) (10):

(1) The period of solicitation of proposals by public advertisement shall be ten days in lieu of twenty days;

(2) In any case in which such site or land is to be acquired by condemnation, the provisions of section 355 of the Revised Statutes, as amended, shall not apply; and

(3) Notwithstanding the provisions of section 1 of the Act entitled "An Act to expedite the construction of public buildings and works outside of the District of Columbia by enabling possession and title of sites to be taken in advance of final judgment in proceedings for the acquisition thereof under the power of eminent domain," approved February 26, 1931 (U. S. C., Supp. V, title 40, sec. 258a), in any case in which any land or any interest therein is to be acquired by condemnation, the Secretary of the Treasury, through the Attorney General, may, prior to the institution of condemnation proceedings, file with the clerk of the district court of the district in which

such land is located a declaration of taking, containing the matters required by such section to be included in a declaration of taking. The declaration of taking shall be accompanied by the deposit with such clerk, to the use of the parties who may be found to be entitled thereto, of the amount of the estimated compensation stated in the declaration.

As soon as practicable after the filing of such declaration of taking, the Secretary of the Treasury shall cause to be posted in a prominent place upon the land a notice reciting (A) that the land or the interest therein is taken by the United States for public use, (B) that a declaration of taking in respect of such land or interest therein has been filed with the clerk of the court of the district, and (C) that there has been deposited with such clerk, to the use of the parties who may be found to be entitled thereto, the estimated just compensation for the land or interest therein taken.

The Secretary of the Treasury shall give written notice similar to the posted notice, by personal service in the case of actual occupants of the premises or, if with reasonable diligence such personal service can not be made, he shall send such notice by registered mail directed to the premises, and he shall send notice by registered mail directed to their last known address in the case of all parties who the Secretary ascertains have or may have an interest in such land, and he may give such additional notice by newspaper publication or otherwise as he deems necessary.

Upon posting notice on the land, title to the land or interest therein shall vest in the United States, and the right to just compensation therefor shall vest in the parties entitled thereto. The Secretary of the Treasury shall cause notice to be personally served upon, or if with reasonable diligence such service can not be made, to be sent by registered mail to actual occupants of the premises, setting a time (not earlier than twenty days after the service or sending of such notice) at which such parties shall surrender possession, and at the end of such time the right to possession shall vest in the United States.

The Secretary of the Treasury may designate any person to serve any notice under the preceding provisions of this subsection and such person shall have power to enter upon such land for the purpose of posting notice or to make personal service of notice. If any such party fails or refuses so to surrender possession, upon

summary petition for an order to surrender possession filed in such district court by or on behalf of the Secretary of the Treasury, the court may, by writ of assistance or other process, order the surrender of possession.

A petition in condemnation shall be filed in such district court as soon after the filing of the declaration of taking as practicable. In any such condemnation proceeding, no further declaration of taking shall be required, and the provisions of section 1 of such Act of February 26, 1931, authorizing the court to fix the time when parties in possession shall be required to surrender possession, shall not apply. If such petition for condemnation is not filed within a reasonable time after the filing of such declaration of taking, any person entitled to just compensation in respect of the property so taken shall be entitled to sue the United States in the court in which such declaration of taking was filed.

The procedure in such suit shall be the same as in suits against the United States founded upon contract, except that such suit may be heard even if the amount of the claim is greater than $10,000 and except that the procedure for the ascertainment of the amount of just compensation shall be the same as such procedure in condemnation proceedings. If the petition for condemnation is filed prior to the time the commissioners in condemnation, jurors, or other persons charged with the duty of valuing the property are empaneled, such suit shall be dismissed, except that such suit and the condemnation proceedings may, in the discretion of the court, and under rules prescribed by it, be consolidated to such extent as the court may deem practicable.

In any suit authorized to be brought under this subsection or in any condemnation proceeding involving land acquired in accordance with this subsection, the court shall enter judgment against the United States in favor of the parties entitled for the sum or sums awarded as just compensation, respectively, for the land or interest therein taken for the use of the United States and such judgment shall be paid out of the sums deposited with the court and such additional sums as may be awarded shall be paid in the same manner as sums awarded in judgments in cases in which the United States has consented to be sued.

The provisions of such Act of February 26, 1931, except as modified

by this subsection, shall apply to all such suits or condemnation proceedings. The provisions of this subsection shall not be construed to be in substitution for, but shall be supplemental to, any method of acquiring land or interests therein provided in existing law.

Sec. 306. In the construction of post offices and of buildings for post offices and other offices provided for in section 301 (a) (10), the Secretary of the Treasury with the coöperation of the Postmaster General may use such standard plans (heretofore or hereafter prepared) as may be most adaptable to the particular building to be constructed.

Sec. 307. All contracts let for construction projects pursuant to this title shall be subject to the conditions that no convict labor shall be directly employed on any such project, and that (except in executive, administrative, and supervisory positions), so far as practicable, no individual directly employed on any such project shall be permitted to work more than thirty hours in any one week, and that in the employment of labor in connection with any such project, preference shall be given, where they are qualified, to ex-service men with dependents.

Sec. 308. For each fiscal year beginning with the fiscal year 1934, there is authorized to be appropriated, for the purposes of the sinking fund provided in section 6 of the Victory Liberty Loan Act, as amended, in addition to amounts otherwise appropriated, an amount equal to 2½ per centum of the aggregate amount of the expenditures made, out of appropriations made or authorized in this title, on or after the date of the enactment of this Act and on or before the last day of the fiscal year for which the appropriation is made.

DISCUSSION

In Mr. P. J. Hurtgen's article[1] on unaccounted for water the following statement is quoted from Mr. Howson: "There is need of an accurate means for testing water meters at small flows without removal from service."

The writer suggests that by placing a petcock just inside the meter, between the meter and the stopcock, small meters may quickly and readily be tested in place. The procedure is simply to close the stop and waste and then draw water from the petcock at any desired rate of flow into either a five gallon or cubic foot container. Checking the quantity shown by the small register of the meter against that drawn from the petcock provides a simple and accurate test of the meter.

Since in many systems a considerable percentage of the unaccounted for water is caused by the failure of meters to register the small flows, periodic tests of this sort would result in a saving which would more than pay for the tests.

CHARLES M. MOWER, JR.[2]

[1]Journal, April, 1932, page 514.
[2]Ithaca, N. Y.

SOCIETY AFFAIRS

THE FOUR STATES SECTION

The 1932 annual meeting of the Four States Section, was held on June 7 and 8, 1932, at the Madison Hotel, Atlantic City, N. J.

The meeting was called to order promptly at 10:30 a.m. on Tuesday, June 7, by Chairman L. Van Gilder, Engineer and Superintendent of the Atlantic City, New Jersey, Water Department.

Owing to the unexpected absence from the City of Mayor Harry Bacharach, the delegates were welcomed to Atlantic City by Chairman Van Gilder.

The first paper on the program was a very interesting history of the Atlantic City Water Supply by Chairman Van Gilder.

Mr. David G. Thompson, Senior Geologist, Water Resources Branch, United States Geological Survey, Washington, D. C., presented a most interesting and instructive paper on the underground water conditions in the Atlantic City region. It was well illustrated by lantern slides and was discussed at some length.

The subject was one of great interest and a resolution was passed requesting that Mr. Thompson's paper be printed in the American Water Works Journal.

The afternoon session started with a business meeting and the election of officers.

Mr. H. T. Critchlow, Division Engineer, New Jersey State Water Policy Commission, Trenton, N. J. was elected Chairman.

Mr. Sheppard T. Powell, Chemical Engineer, Baltimore, Maryland was elected Vice-Chairman.

Mr. Charles H. Becker of R. D. Wood and Company, Philadelphia, Pennsylvania was re-elected Secretary and Treasurer.

Mr. H. S. R. McCurdy, Chief Engineer, of the Philadelphia Suburban Water Company, Bryn Mawr, Pennsylvania, and Mr. W. Compton Wills, Chief Engineer and Superintendent of the Wilmington Water Department, Wilmington, Delaware, were elected trustees to serve two years.

Upon the invitation of Chairman Van Gilder, Col. Willard T.

Chevalier, Publishing Director of Engineering News-Record, New York City, addressed the meeting on the subject of the Water Works Betterment Program sponsored by the A. W. W. A., and reported on the action of the A. W. W. A. during its convention at Memphis and explained clearly the several bills now under consideration by Congress.

A resolution was passed endorsing and seconding the action of the A. W. W. A. at Memphis, and as a means for carrying out its provisions, the Wagner Bill now before Congress was approved.

A telegram was sent to the eight senators from the four states comprising the Section, advising of the action taken and requesting their support of the Wagner Bill.

The Chairman reported on the recent unsuccessful movement to form a separate New Jersey Section of the A. W. W. A.

A letter ballot was sent out by the General Secretary's office to all New Jersey members of the A. W. W. A., and the majority of votes returned were not in favor of forming a separate Section.

The Chairman expressed the gratification and appreciation of the Section that the New Jersey members elected to continue with the Four States Section.

The balance of the afternoon was taken up by a paper on the Washington Suburban Sanitary District by Harry R. Hall, Deputy Chief Engineer, Hyattsville, Maryland. This was discussed by George W. Fuller and Abel Wolman. A question box and superintendents' discussion was conducted by Mr. Abel Wolman of Baltimore, Md.

The evening's entertainment, "A Bavarian Saenger-Fest," was thoroughly enjoyed and voted a success.

During the evening, Mr. B. C. Little, Secretary of the A. W. W. A., addressed the members and reported on the happenings at Memphis. Mr. Little's report on some of the amusing incidents occurring at Memphis, was received with gales of laughter.

The morning session on Wednesday, June 8, was taken up by papers and general discussions. A paper on "The Water Resources Commission of Maryland" was presented by Abel Wolman and on "The Effect of Salinity on the Value of Water Uses for Industrial Purposes" by Sheppard T. Powell. A general discussion on taste and odors was led by L. L. Jenne and was participated in by F. E. Stuart and F. C. Schmelkes. In the afternoon there was a trip arranged to inspect the new Atlantic City Water Supply at Absecon, including the inspection of the well fields and the pumping plant.

The officers of the Section were highly gratified at the attendance and express their appreciation, especially to the manufacturers' representatives, for their support and cooperation.

CHARLES H. BECKER,
Secretary-Treasurer.

ABSTRACTS OF WATER WORKS LITERATURE[1]

FRANK HANNAN

Key: American Journal of Public Health, **12**: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

Sterilizing Action of Silver and Copper on Bacteria. C. EGG and A. JUNG. Mikrochem. 1929, Pregl Festschr., 46–60. From Chem. Abst., **24**: 3529, July 20, 1930. Cultures of *B. coli* were sterilized within 24 hours by 0.04 mgm. of silver per liter and marked effect was produced with concentrations as low as 0.001 mgm. Active principle is silver ion, slightly dissociated silver salts such as silver sulfide having no effect. Colloidal solutions of silver and solutions containing complex silver ions may also in certain cases act as sterilizers, but this action is due to liberation of silver ions through secondary reactions. Sterilizing effect of copper compounds is due, likewise, to copper ions, but in this case minimum concentration of 0.6 mgm. per liter is necessary for complete sterilization. No other metals have been found with sterilizing power equal to above.—*R. E. Thompson.*

The Poisonous Action of Some Metals and Alloys on Bacteria. GUSTAV TAMMANN. Forschungen u. Fortschritte, **5**: 257, 1929. J. Inst. Metals, **42**: 693, 1929. From Chem. Abst., **24**: 3529, July 20, 1930. About 0.3 mgm. of copper or from 10^{-3} to 10^{-6} mgm. of silver per liter renders oxygenated water poisonous to bacteria. If, for example, piece of metal is immersed in culture of bacteria, zone completely free from bacteria forms around metal in case of poisonous action. Limits of zone depend on concentration of dissolved metal, on rate of diffusion, and on rate of growth of bacteria. Manganese, aluminum, and iron appear to be non-poisonous, but cobalt and nickel are poisonous. Gold-silver alloys are poisonous only when silver content exceeds 50 atomic percent [i.e. 35.4 percent by weight.—Abstr.]—*R. E. Thompson.*

Filtrator Feed Water Treatment. Filtrators, Ltd. Indian Textile J., **40**: 284–5, 1930. From Chem. Abst., **24**: 3584, July 20, 1930. Use of linseed mucilage, added to boiler water, as scale preventative is discussed.—*R. E. Thompson.*

Determination of the pH of (Natural) Waters with the Quinhydrone Electrode. KURT BUCH. Soc. Sci. Fennica Commentationes Phys.-Math., **4**:

[1] Vacancies on the abstracting staff occur from time to time. Members desirous of coöperating in this work are earnestly requested to communicate with the chief abstractor, Frank Hannan, 285 Willow Avenue, Toronto 8, Ontario, Canada.

21, 1–10, 1929; cf. C. A., **24**: 2363. From Chem. Abst., **24**: 3581, July 20, 1930. Measurements of pH of salt-containing waters were made with quinhydrone electrode against hydrogen electrode, and with each of these against calomel electrode. Salts occurring in sea water have practically same effect on quinhydrone potential as sodium chloride. The pH as observed with this electrode in sea water should be corrected by subtracting 0.0008 times percentage salt concentration.—*R. E. Thompson.*

Chemical Precipitation of Humic Pigments (in Water Purification). I. C. P. Mom. Mededeel. Dienst Volksgezondheid Nederland.-Indie, **18**: 422–30, 1929. From Chem. Abst., **24**: 3583, July 20, 1930. Coagulation of humic matter by means of aluminum sulfate is effected by simultaneous influence of hydrogen ions, aluminum ions, and colloidal aluminum oxide. If ferric salt is used as coagulant, coagulation is effected by simultaneous influence of hydrogen ions, ferric ions, and colloidal ferric oxide. If, in these processes, free chlorine is present, part of organic matter is withheld from coagulating by destructive effect of chlorine upon humus colloids.—*R. E. Thompson.*

How Operating Conditions Affect Chemical Feed Treatment. D. C. Carmichael. Power, **71**: 702–5, 1930. From Chem. Abst., **24**: 3584, July 20, 1930. Directions given for testing water for alkalinity and for chloride content.—*R. E. Thompson.*

Activated Carbon: A Modern Purifying Agent. Charles L. Mantell. Food Ind., **2**: 207–9, 1930. From Chem. Abst., **24**: 3610, July 20, 1930. Standard methods of testing, or judging, carbons have little practical value. Carbons can attract and retain anything in a liquid that constitutes an impurity, particularly if that substance is of higher molecular weight than substance in which it occurs, or if it is in form of colloids which can be adsorbed on surface of carbons. Adsorbing power of carbons, in general, varies with amount of active surface per unit of weight. Since most of colored materials encountered in industry are negatively charged, ordinary carbons give greater decolorization with increase in acidity of solution. Various applications are discussed.—*R. E. Thompson.*

Hypochlorite Corrosion is Cut by Addition of Salts and Bases. G. N. Quam. Food. Ind., **2**: 121–2, 1930. From Chem. Abst., **24**: 3610, July 20, 1930. Trisodium phosphate, from 0.1 to 0.5 percent, added to sodium hypochlorite solutions causes marked lowering of corrosive action on metals. Admixture of 0.5 percent sodium hydroxide-sodium carbonate, or of 0.1 percent calcium hydroxide, has similar action. Rate of deterioration of sodium hypochlorite stabilized with sodium hydroxide is lower than of that stabilized with sodium phosphate. Germicidal value is probably unimpaired by addition of detergents.—*R. E. Thompson.*

Superheaters for High Steam Temperatures. W. Orth. Wärme, **53**: 227–9, 1930. From Chem. Abst., **24**: 3676, August 10, 1930. New method is described which shows that superheater tubes of SM steel are subject to internal corrosion, even when steam is free from impurities and air, if steam tempera-

tures of 500° are exceeded. Suggestions are given for design of superheaters for steam.—*R. E. Thompson.*

Natural Waters Rich in Radium. W. VERNADSKY. Compt. rend., **190**: 1172–5, 1930. From Chem. Abst., **24**: 3706, August 10, 1930. Recent papers bearing on this subject are reviewed. It is pointed out that natural waters rich in radium constitute new source of radium. Dissolved radium decomposes water. Concentrations as high as 1.5×10^{-8} percent have been observed. —*R. E. Thompson.*

Welding of Copper Vessels and Pipe. S. MASHL. Welding Eng., **15**: 4, 55–7, 1930; Acetylene J., **31**: 422–4. From Chem. Abst., **24**: 3738, August 10, 1930.—*R. E. Thompson.*

Electric Currents Carried in Pipe Lines. STANLEY GILL and W. F. ROGERS. Oil and Gas J., **29**: 3, 158–T, 160, 164, 167, 171, 1930. From Chem. Abst., **24**: 3635, July 20, 1930. Electric current in pipe lines may be measured directly on pipe or in ground in contact with pipe. Second method is not usually practicable for "long-line currents." Potential drop along line may be measured by millivoltmeter, or by potentiometer; preferably by latter, because it consumes no current. From potential drop, weight per foot of pipe, and resistance of pipe metal, current flowing can be calculated. Galvanic action is set up when two electrolytically different metals are placed in contact. When new pipe comes in contact with old, current passes from new to old through soil. Compacting of soil around pipe, wetness of soil and its saline and oxygen contents, depth, recent rainfall, and passage of line through stream bed or swamp are factors. Magnetic storms are probably negligible in their effect. Local galvanic currents are probably main cause of pipe line corrosion. Even highest rate of current discharge measured cannot have appreciable effect, if discharge is spread uniformly over pipe; but if long-line currents are discharged from small areas, pitting may result. There is no reason to suppose that they affect the inhibition of corrosive action by cathodic polarization upon parts of line that are picking up current. Investigations are not sufficiently advanced to warrant final conclusions as to corrosive action of long-line currents.—*R. E. Thompson.*

Two Delicate Tests for the Detection of Copper with Some Remarks on the Rhodanine Test of Feigl for Silver. I. M. KOLTHOFF. J. Am. Chem. Soc., **52**: 2222–6, 1930. From Chem. Abst., **24**: 3726, August 10, 1930. Delicate and simple test with *p*-dimethyl-aminobenzylidene-rhodanine is described. CLARKE and JONES test for copper (C. A., **23**: 4637), using dimethylglyoxime and persulfate together with silver nitrate, has been modified by using trace of periodate as oxidizing agent. As little as 0.1 p.p.m. of copper can be detected.—*R. E. Thompson.*

Safeguarding Emergency Water Supplies. LINN H. ENSLOW. Eng. News-Rec., **106**: 838–41, 1931. Chlorination of emergency water supplies is discussed and emergency measures employed at various cities during 1930 drought to safeguard and render palatable such supplies are outlined. At

Luke, Md., Fe, Mn and Al in Potomac River water caused considerable difficulty. Aëration, prechlorination, and application of sufficient NaOH to increase pH value to 10, or higher, was necessary to completely remove Mn. Prechlorination and slightly increasing the alkalinity removed the Fe and Al and half the Mn. Taste and odor troubles were prevalent and almost every known means of correction was tried. Ammonia was effective in some places and not at others: at two towns the phenol content of the water was too great for taste to be prevented by preammoniation. Powdered activated carbon applied to raw water, or to coagulated water prior to filtration, proved effective at a number of plants. Under most severe conditions, quantity required was 1 grain per gallon, or more. Superchlorination and dechlorination with activated carbon proved to be the most effective means of bacterial destruction and taste elimination. For odor elimination, $KMnO_4$ treatment frequently proves superior to other chemical applications, particularly when odor is due to decaying diatoms.—*R. E. Thompson* (*Courtesy Chem. Abst.*).

Managua Water Works Restored by Army Engineers. Eng. News-Rec., **106**: 841, May 21, 1931. Brief details given regarding work of Army Engineers in restoring water supply of Managua, Nicaragua, destroyed by earthquake on March 31, 1931. Temporary plant on shore of Lake Managua was put in operation on April 6, pumping into old supply main. The pumping plant on Lake Asososca was dug out in 5 days and a 30-foot wall of heavy timber erected to prevent damage by further slides. One of the 2 pumps was in operation again on April 9. One break was found in the spiral-riveted steel discharge line from pumping plant to reservoir. This was repaired by inserting a section of cast iron pipe.—*R. E. Thompson.*

Quality of the Border Cities' Water Supply. G. H. STRICKLAND. Cont. Rec. and Eng. Rev., **45**: 282–5, 1931. Data are given regarding operation of Essex Border Utilities Commission purification plant treating Detroit River water. Coagulant is applied in suction well, mixing being effected by passing through centrifugal pumps and in an "over and under" baffled basin. Difficulties due to algae are experienced during early summer months. In 1927, filter runs during "algae period" dropped as low as 1 hour and 20 minutes, the average for whole month of June being less than 6 hours. A minimum length of run of 10 hours was obtained in 1928 and 1929 by substituting iron and lime for alum during period of short runs. Maximum turbidity in filter influent compatible with production of satisfactory effluent has been found to be 30 p.p.m. Prechlorination (0.15 p.p.m.), adopted as a plant scale experiment in May, 1930, reduced coagulant costs 50 percent and increased filter runs 30 percent as compared with previous two years. Effluent conformed to U. S. P. H. S. standards at all times, and conduits, walls, troughs, and filter sand were decidedly cleaner. The chlorine had a marked effect on coagulation, alum floc at entrance of coagulation basin being in form of fine, hair-like particles which agglomerated in first quarter of basin to large stringy masses (up to 1 inch in length) which settled rapidly. Size of the masses appeared to bear some relationship to plankton count and to water temperature. In absence of chlorine floc consists of spongy, irregular, disc-shaped masses ranging in size from a "pin point" to a maximum diameter of $\frac{1}{16}$ inch. It has

been observed that turbidities of from 30 to 50 p.p.m. retard this action of chlorine, effect practically disappearing when turbidity is 50 p.p.m. or higher. During first 3 years of operation, filter sand, which originally had an effective size of 0.46 mm. and uniformity coefficient of 1.4, accumulated a coating varying from 10.95 percent on top most ½ inch of sand to 1.48 percent at depths below 12 inches. During past year, sand of 0.5 mm. effective size and 1.38 uniformity coefficient has been added, increasing sand bed depth from 28 to 38 inches. During years 1926–9, cost of operation varied from $12.38 to $13.50 per million gallons.—*R. E. Thompson* (*Courtesy Chem. Abst.*).

Multiple Arch Dam and 9-Mile Wood Stave Pipe. W. GRIESBACH. Cont. Rec. and Eng. Rev. 45, 476–9, April 22, 1931. Description of recently completed water supply system of Dalhousie, New Brunswick, mill of International Paper Company, consisting of dam on Charlo River, 9 miles of 32-inch wood stave pipe, cast iron syphon under Eel River, and 3 tunnels through which line passes. Dam is of concrete multiple arch type, 360 feet wide and 87 feet high, embracing 11 arches of varying height. Pipe line traverses great variety of country. At river crossing, 1200 feet of flexible jointed pipe was employed, laid 4 feet under natural river bottom. Wood stave pipe is of 32 inches inside diameter, constructed of staves 1⅝ inches thick, secured by ¾-inch steel bands. Band spacing varies from 10 inches at inlet, where head is 30 feet, to 3¼ inches at mill, where head is 157 feet. Three coats of Protexol paint were applied by gun: a total of about 1 million square feet. Provisions has been made at dam and in tunnels for second 32-inch pipe line.—*R. E. Thompson.*

Directory of Important Water Works Systems of Canada. Cont. Rec. and Eng. Rev., **45**: 204–11, March 11, 1931. Authoritative and up-to-date data concerning water supplies of leading cities and towns throughout Canada.—*R. E. Thompson.*

Effective Oil-Waste Disposal. Eng. News-Rec., **106**: 816, May 14, 1931. Data are given from annual report of Santa Fe Springs Waste Water Disposal Company, which has been in operation more than 1 year. Membership has increased until now 33 oil companies, practically every one in district, are members. Plant, which consists of settling and skimming basins, has been handling daily average of 79,411 barrels of water, 75 per cent more than contemplated. During year, oil recovered and sold amounted to 53,820 barrels, revenue derived from this source being more than $20,000, or almost half of total operating expense. Oil content of water discharged into ocean (at point 15 miles from plant) is less than 10 p.p.m. Despite overload, total plant investment of $487,000 represents increase of only 8 per cent beyond original estimate. Cost of treatment, which amounted to 1½ mills per barrel, was pro-rated on basis of members' daily average contributions.—*R. E. Thompson.*

Gate Handling at Calderwood Dam. ADOLPH J. ACKERMAN. Eng. News-Rec., **106**: 754–7, May 7, 1931. Improved mechanical equipment, described and illustrated, permits one-man operation of entire flood-gate and outlet-works of Calderwood Dam of Knoxville Power Company on Little Tennessee River.—*R. E. Thompson.*

Cofferdams and Stream Control at Jordan Dam, Alabama. LEE WARREN. Eng. News-Rec., **106**: 804–8, May 14, 1931. Detailed description of cofferdam construction and general closure procedure at Jordan Dam, built on Coosa River for Alabama Power Company.—*R. E. Thompson.*

Progress on Rio Grande Conservancy Project. Eng. News-Rec., **106**: 759, May 7, 1931. Brief outline of progress on Middle Rio Grande Conservancy District $10,000,000 project for flood control, drainage, and irrigation over area of 123,300 acres in central part of New Mexico. About 17 per cent of 4-year construction program has been completed.—*R. E. Thompson.*

Conservancy Laws Adapted to Irrigation Development. J. L. BURKHOLDER. Eng. News-Rec., **106**: 758, May 7, 1931. Outline and discussion of New Mexico conservancy law, under provisions of which Middle Rio Grande District functions.—*R. E. Thompson.*

Weather's Effect on Water Demand Discloses Sprinkling Load. ARTHUR H. MILLER. Eng. News-Rec., **106**: 762–3, May 7, 1931. Graphs are given showing hourly pumpage at Sheboygan, Wisconsin, on 3 days during summer of 1930. Supply is drawn from Lake Michigan. There is no storage reservoir, or tank, pump feeding directly into mains, and even minor fluctuations in demand are reflected in pumpage. Study revealed close relationship between consumption and hourly variations in weather conditions and indicated volume of elevated storage required. On one day indicated sprinkling demand varied from 3.6 million gallons at noon to nearly 11 million gallons at 7 p.m., latter representing approximately 75 percent of total load at that time.—*R. E. Thompson.*

Brantford, Ontario, Completes New Filtration Plant. FRANK P. ADAMS. Cont. Rec. and Eng. Rev., **45**: 495–7, 1931. Brief description of new plant treating Grand River water, and consisting of mixing chamber, sedimentation basins, six 1-million-gallon per day rapid sand filters, and 1-million-gallon reservoir. Chlorine is applied before water passes to high-lift pump suction wells. Low-lift pumping equipment consists of 3 direct-connected vertical pumps and motors, and high-lift equipment comprises two 6-million-gallon per day horizontal, direct-connected, motor-driven pumps and one 4-million-gallon unit. Diesel engines, direct-connected to electric generators, are stand-by drive and are also used to furnish current to local hydro-electric system during daily peak load periods.—*R. E. Thompson* (*Courtesy Chem. Abst.*).

Methods of Keeping Hydrants from Freezing. R. L. DOBBIN. Cont. Rec. and Eng. Rev., **45**: 385–6, April 1, 1931. Procedure employed in Peterborough, Ontario, for minimizing freezing of hydrants is outlined. All hydrants should be well drained to stone pockets of sufficient size to hold at least twice the volume of hydrant barrel. Hydrants should be oiled and put in first class condition in fall and continuous inspection should be commenced after first frost. In Peterborough, 1 man inspects 350 hydrants twice each week through-

out winter. Moderate amounts of ice are removed with aid of sodium chloride, or of calcium chloride. Salt, even when kept all winter in hydrants with leaky valves, has been found to have very little effect on metal parts, but valve leathers must be renewed in spring. Steam thawing of hydrants is much more rapid than electric thawing and, in addition, warms surrounding ground and prevents freezing for longer time. Electric thawing of services has been found economical, efficient, and rapid. It does not warm the ground as steam would, however, and it is necessary to allow a house tap to run during remainder of winter. Only permanent remedy is to relay pipe at greater depth. —*R. E. Thompson.*

The Water Supply Problem in Southern Saskatchewan. W. A. JOHNSTON. Cont. Rec. and Eng. Rev., 45: 297–300, 1931. Discussion of mode of occurrence of ground water and of methods of prospecting for ground water supplies, together with outline of results of investigations recently made in connection with supplies of Regina and of Moose Jaw. Large supplies of ground water are available in but few places. Average annual precipitation over much of region is only from 10 to 15 inches, rate of evaporation and transpiration by plants in summer is extremely high, and during winter, comparatively little water can enter the frozen ground. South Saskatchewan River is only stream from which large supplies of soft water may be obtained. Supply of Moose Jaw is derived from several sources yielding limited volumes, part being obtained from springs and remainder from impounded and seepage water in Thunder Creek valley.—*R. E. Thompson* (*Courtesy Chem. Abst.*).

Methods of Driving One-Mile Railway Tunnel Under City of Quebec. Cont. Rec. and Eng. Rev., 45: 351–5, March 25, 1931. Illustrated description of methods employed in constructing Canadian Pacific Railway tunnel, 1 mile in length, under Quebec City. Width of tunnel is 16 feet and height at center line is 22 feet 6 inches. Tunnel will be lined with concrete.—*R. E. Thompson.*

Ottawa's Method of Thawing Frozen Services. Cont. Rec. and Eng. Rev., 45: 295, March 11, 1931. Electric thawing machine, designed by W. E. MACDONALD, had saved city $23,028 to close of last winter. Apparatus is self-contained power plant, generating sufficient current to thaw pipe up to 6 inches in diameter. As it is gasoline engine-driven, connections to outside wires, with their risks, are eliminated. First 725 frozen services were thawed at cost of $1.78 each, as compared with cost of $6.05 per service in 1918 by transformer method.—*R. E. Thompson.*

Municipal Engineering in Singapore. HAROLD E. BABBITT. Eng. News-Rec., 106: 1009–12, 1931. Water supply of Singapore, obtained from 5 impounding reservoirs, is purified in 2 slow sand filter plants of 11- and 25-million-gallon per day capacities and a 12.5-million-gallon per day rapid sand filter plant. At latter plant, lime is employed to aid in removal of Fe, and alum is added as coagulant, water flowing directly onto filters after addition of the chemicals, neither mixing nor coagulation basins having been provided. —*R. E. Thompson* (*Courtesy Chem. Abst.*).

Low Water Table Forecasts Small Autumn Streamflow. Eng. News-Rec., 106: 866, May 21, 1931. It is pointed out that, due to diffusion in underground storage, only excessive rainfall during next few months will prevent autumn streamflow from dropping to lower levels than last year. Replenishment of ground water ordinarily begins in January after vegetation becomes dormant: this year, no improvement was indicated until latter part of March. Little further improvement in ground water conditions is expected from now on, as most of rainfall, except that which escapes as surface water, is absorbed by vegetation. Failure of replenishment early this spring will probably result in depression of water table to new low stages next summer and autumn.—*R. E. Thompson.*

Lessons from the 1930 Drought. J. F. LABOON. Eng. News-Rec., 106: 836–8, May 21, 1931. New records for low rainfall and minimum stream flow were established during 1930, while peak demands for water in many cities were higher than ever before. Lack of meters and low rates to large consumers are shown to be important factors affecting demand. Heretofore, in estimating runoff in eastern states, minimum runoff values of 0.07 and, more recently, of 0.04, second-foot per square mile have been assumed; but zero values have now been recorded for some streams. Further, it has hitherto been considered good practice to employ value of 0.5 million gallons per day as safe yield of completely impounded stream: this value must now be reduced to, at most, 0.4 million gallons.—*R. E. Thompson.*

Filter Sand and Effective Size (A Symposium of Authoritative Views on Needed Change in Hazen's Definition). Eng. News-Rec., 106: 770–2, May 7, 1931. **For Slow and Rapid Filters.** MALCOLM PIRNIE. The Lawrence experiments indicated that effective size was controlling factor in flow of water through sand found and used in natural state. To assure comparable results, the mechanics of determining effective size and uniformity coefficient must conform exactly to original methods. Writer's firm have always had entire satisfaction in use of sands selected for slow sand, or mechanical, filters under specifications for allowable limits of effective size and uniformity coefficient. **Hazen's Attitude.** PAUL HANSEN. Writer points out that HAZEN never proposed that effective size and uniformity coefficient should be used in specifying sands for filters. On contrary, it was his invariable practice to specify the range of sizes with some stipulations regarding very fine and very coarse material. It is questionable whether standard sieve cloths are sufficiently accurate to warrant their use without calibration. Use of terms effective size and uniformity coefficient in specifications of sand for rapid sand filters is, of course, illogical and perhaps undesirable. Their use, however, generally obtains a satisfactory sand, although perhaps a more satisfactory sand could be obtained by specifying percentage of grains of different sizes. **Accurate Statistical Index.** ABEL WOLMAN. Author believes that no index of sand size can be fully interpreted for use in rapid, or slow sand filtration without complete sieve analysis of the sand. Some of difficulties in interpretation of the HAZEN results are due to suggestion that HAZEN himself made that logarithmic plottings of findings be adopted. When this is done, results of sieve

analyses appear on straight line and do not show variations at low and high points which original Hazen method presented and upon which, incidentally, the effective size and uniformity coefficient were predicated. The effective size was merely an arbitrary point which was chosen at point of flexure on a curve of sieve sizes. Review of hundreds of sieve analyses plotted in fashion originally employed by HAZEN shows that the 10 percent figure was chosen on a perfectly logical basis as to where flexure in curve of natural sands always occurred. From similar review of plottings of sieve analyses on an arithmetical base it is apparent that uniformity coefficient, as determined by 60 percent and 10 percent values, was wisely chosen to determine slope of the sand curve. Inasmuch as the 60:10 ratio now has the strength of historical familiarity, there appears to be little reason for switching to another point on curve which would not define the slope mathematically any more correctly. Writer believes that entire sight has been lost of fact that HAZEN method is entirely a procedure for determining size of sand, and that the part of the original contribution in 1892 dealing with sizes best suited for filters was purely incidental. The HAZEN method is as excellent a statistical evaluation of sand size distributions as has so far come to light. **Usefulness Outlived.** ARTHUR R. HOLBROOK. Recent specifications on filter sand for filter plant handling turbid water were: effective size, not less than 0.4, or more than 0.5 mm.; uniformity coefficient, not more than 1.65; not more than 0.2 percent finer than 0.2 mm.; not more than 1 percent finer than 0.25 mm.; and at least 90 percent finer than 0.8 mm. Sand was very satisfactory. Sentiment in writer's firm is that the effective size has rather outlived its usefulness as measure of filter sand and that it would be better to specify amount to be passed through or retained on certain size sieves. **Causes of Difficulties.** G. GALE DIXON. It may be that some index of size other than HAZEN's effective size will prove more apt for selection of sand, but it is obvious that widespread difficulties that have been experienced with sand beds during past 10 or 15 years have been due to failures in cleansing process rather than to any inherent deficiencies of sand. The filters now under construction for the Mahoning Sanitary District have been designed for wash rate of 36 inches vertical rise per minute. The sand bed will be 21 inches deep, and sand will have effective size of 0.40 mm., 30 percent size of 0.50 mm., and uniformity coefficient of less than 1.6. The 6-inch layer of "torpedo" sand overlying the gravel will have an effective size of from 1.0 to 1.5 mm., and uniformity coefficient of not more than 2.00. **Little Trouble Experienced.** J. P. LABOON. Writer's firm have experienced little difficulty attributable to filter sand size. Specifications are based on effective size and uniformity coefficient, with qualifying limits. Recent specification read, in part, as follows: The sand shall have an effective size of not less than 0.35 mm., or more than 0.45 mm., and uniformity coefficient of not more than 1.65. Not more than 0.2 percent shall be finer than 0.20 mm., not more than 1 percent finer than 0.25 mm., and at least 90 percent shall be finer than 0.8 mm. Diameters of sand grains shall be computed as the diameters of spheres of equal volumes and all percentages shall be calculated by weight. **Effective Size Best.** LOUIS R. HOWSON. Practice of writer's firm is to place an excess of sand in beds, usually about 3 inches, and, by washing, bring finest of sand to surface, from which it is removed by skimming. Specifications permit uni-

formity coefficients as high as 1.6. After treatment as outlined above, uniformity coefficient is usually about 1.3. Owing to greater emphasis now being placed upon mixing, coagulation, and settlement, use of coarser sand is believed justified, i.e., from 0.50 to 0.55 mm. as compared with from 0.35 to 0.45 a few years ago. When conditions demand it, latter size is adhered to. **Coarser Sand Now Used.** N. T. VEATCH, JR. Until recently, writer's firm has specified effective size of from 0.35 to 0.47 mm., and uniformity coefficient not to exceed 1.7. Sand with effective size of at least 0.55 mm. will probably be specified in future. It is believed that the work in the filter bed is done in a top layer of sand at least 6 inches deep, and that local sands can often be used and hydraulically graded in the bed itself. Specifications based directly on sieve sizes would mean more from standpoint of filter sand than those based on effective size. **No Uniformity Requirements.** E. SHERMAN CHASE. Until 1927, it was practice of writer's firm to specify washed sand having effective size not less than 0.30 and not more than 0.40 mm., and uniformity coefficient of not more than 1.6. In that year, new filters of Community Water Service Co., Greenwich, Conn., were filled with sand purchased under these specifications, while 2 filters in an extension, which was started before completion of original project, were filled with a local concreting sand of 0.355 mm. effective size and 4.65 uniformity coefficient. All filters were washed at rate of 24–30 inches per minute vertical rise and scraped after a few weeks, about 2 inches of finest material being thus removed. Automatic grading was practically complete in 4 months. The two sands gave filter beds of practically the same physical characteristics, and filtering efficiencies have been equally satisfactory. On basis of these results, sand specifications have been modified and now read as follows (summarized). Any sand of good quality, meeting usual specifications relative to acid-soluble matter, cleanliness, and other general physical characteristics, may be used, provided its effective size lies between 0.35 and 0.45 mm., with no grains larger than will pass a ¼-inch screen. No limit is set for uniformity coefficient, as reliance is placed on a 24- to 30-inch rate of rise during washing to grade the sand properly and prepare the bed for use. **Wider Limits Suggested.** JOSEPH W. ELLMS. Whether sieve analysis data stated in terms of "fineness modulus," as suggested by ABRAMS, or "surface modulus" and "surface median," as proposed by TYLER, are any more descriptive, or illuminating, than HAZEN's "effective size" and "uniformity coefficient" is probably a question that needs more study. Writer believes that both a lower and upper limit for uniformity coefficient should be stated in specifications for filter sand, and is inclined to permit a higher upper limit than has been commonly used in past. Since hydraulic grading by high-velocity washing will rearrange sand grains and since lower layers must be of such size as to prevent them sifting through finest gravel, it seems reasonable to permit greater variation in sizes. Experience at St. Louis in formation of craters in sand bed due to not properly grading upper layers of fine gravel to the coarsest layers of sand is further evidence of need for careful adjustment of fine gravel to the hydraulically graded sand. Craters may form if finer gravel layers are so thin as to be displaced in washing and thereby provide no adequate support for sand bed. Writer believes that sand with effective size ranging from 0.38 to 0.45 mm. will effectively filter most waters. **Revision**

Needed. GORDON M. FAIR. Department of Sanitary Engineering, Harvard University, has studied question of particle size of dusts and sands for some years. It is believed that HAZEN'S parameters of sand size will have to be revised before materials of desired hydraulic performance can be specified. Evidence so far obtained shows that both HAZEN'S "size of separation" and the so-called manufacturer's rating of sieves are not adequate measures of true particle size. It is believed that geometric mean size of particles, together with geometric standard deviation obtained by direct measurement under microscope, or by microscopic projection, represents more truly both the central tendency and the dispersion of particle size, both of sample of sand as whole and of component portions separated by sieving. Furthermore, it is believed that "mean-surface-area diameter" or the diameter of particles having average surface area may be truer measure of hydraulic characteristics of sand than is the effective size. This seems to be particularly evident in case of sands with uniformity coefficient less than 2.64, at which point the effective size and the mean surface area diameter are identical. HAZEN worked with uniformity coefficients less than 5 and probably nearer to this value than to the lower values employed in rapid sand filters. Preliminary tests seem to indicate that for sands of low uniformity coefficient the effective size is much smaller than the size that probably governs the hydraulics of the sands.—*R. E. Thompson.*

Supreme Court Approves Limited Diversion from Delaware by New York City. Eng. News-Rec., **106**: 777–8, May 7, 1931. Adhering very closely to recommendations of the special master in case of State of New Jersey *vs.* State and City of New York, the United States Supreme Court on May 5 handed down decision permitting average diversion of not more than 440 million gallons per day from watershed of Delaware River for use by New York City for water supply purposes. Conditions attending granting of permit are outlined. Development of East Branch and Neversink tributaries of Delaware, together with Rondout Creek, will be begun as rapidly as necessary lands can be secured. Work will extend over 12-year period and, it is estimated, will cost $272,587,000. It will include 3 dams and reservoirs with connecting tunnels as well as additions to, and reconstruction of, parts of present Croton system and Kensico and Hill View reservoirs. East Branch and Neversink reservoirs will be connected with Rondout Reservoir by tunnels 22 miles and 1 mile long, respectively. Rondout reservoir will connect with present Croton system through a 49-mile tunnel which will cost $78,859,000.—*R. E. Thompson.*

Possibilities and Limits of the Water-Sewage-Water Cycle. KARL IMHOFF. Eng. News-Rec., **106**: 883–4, 1931. It is pointed out that reclamation of sewage as an adjunct to water supply is not, strictly speaking, in conflict with water supply practice, river water frequently being nothing less than diluted sewage. In the Ruhr district in Germany, water supplies are derived from filter galleries fed partly from the river and underground flow and partly from filter basins to which water is pumped from the Rhine. During dry summer of 1929, no upland water reached mouth of the Ruhr during a period of several weeks, and it is estimated that in a distance of 56 miles the water passed

3 times through the cycle from public water supply to sewage. The purification process to which the water was subjected in these cycles consisted of mechanical or biological sewage treatment, self-purification of river water (with average flow period of 12 days for each cycle), and soil filtration at the water works. Water supplied during this period was always of the best quality, its taste was satisfactory, and incidence of typhoid was never lower. Laboratory experiments were conducted to determine the number of times this cycle could be repeated. The experimental plant consisted of sewage tank, aeration tank (activated sludge), clarification basin, slightly aerated fish pond, coarse sand filter, and vessel for purified water. In this plant, 13.2 gallons of sewage was treated daily for 99 days, the estimated flowing-through period being 9 days. The sewage was produced daily from 13.2 gallons of returned purified water, 0.13 gallon of urine and 0.26 gallon of fresh sludge. The water was thus polluted and repurified 11 times during the period. Compensation was made for loss through sampling and evaporation, which, during the 99 days, amounted to half the water volume. After the fifth cycle, 4 of the 18 fish in fishpond succumbed due to acidulation of the water by nitric acid produced during biological purification, the pH value having dropped to 4.5. This was corrected by addition of soda and lime to give pH value of 7.2. Lime was again required after the eleventh cycle. Tabulated data are given showing the pH value, Cl^-, $KMnO_4$ consumption, org. N, NO_3^-, NO_2^-, and free ammonia contents of the original water and of the water after the first and eleventh cycles. From these data it is concluded that the practical limit of recovery of potable water from sewage is that of excessive salinity. The chloride content increased during the 11 cycles from 48 to 380 p.p.m., i.e., to the limit of taste. There is little doubt that water could be re-used 10 times. Addition of 10 percent of fresh water to the reclaimed water, plus the evaporation loss, would correct for the increasing salinity.—*R. E. Thompson* (*Courtesy Chem. Abst.*).

Protecting Steel Pipe Lines with Thin Concrete Covering. Eng. News-Rec., **106**: 817, May 14, 1931. Data are given on results of experiments carried out by Portland Cement Association with view to reducing cost and improving methods of applying concrete coatings to steel pipe. Experiments were also made to determine resistance of concrete coverings to possible circumferential increase of pipe due to internal pressure, the value of reinforcement in this connection, and the effect of cushion between pipe and concrete. Pressures up to 1000 pounds per square inch were built up by filling with water and then introducing nitrogen. Increase in diameter of 0.00011 inch was recorded by strain gage on unreinforced section of $8\frac{5}{8}$-inch pipe under 1000 pounds pressure, while reinforced section, on which concrete was applied over thin coating of asphaltic emulsion, showed increase in diameter of 0.00005 inch. Concrete covering was $1\frac{1}{4}$ inches thick. Similar tests were made on gunite covering. It was concluded that concrete coatings should be at least 1 inch thick. About 0.3 percent of reinforcement should be placed circumferentially around pipe, with longitudinal wires to hold main reinforcement in position. It is important that reinforcement have a minimum covering of $\frac{1}{2}$ inch. If vibrator is not used to compact concrete, greater thickness should be used.

Concrete should be dense and dry, and free from honeycombing and segregation. List is included of pipelines on which concrete coverings have been successfully employed, some of which have been in service as long as 16 years. —*R. E. Thompson.*

Drainage Works for the New Madrid Floodway. T. T. KNAPPEN. Eng. News-Rec., 106: 878–82, May 28, 1931. Detailed description of drainage works of New Madrid Floodway, which involve about 15 per cent of total construction costs.—*R. E. Thompson.*

Ammonia-Chlorine Reactions and Chloramine Production in Water and Sewage Treatment. LINN H. ENSLOW. Cont. Rec. and Eng. Rev., 45: 291–5, 1931. Some of the more important and established NH_3-Cl_2 reactions are outlined and discussed. Rôle played by NH_3 compounds in disinfection with Cl_2 was first recognized by S. RIDEAL (J. Roy. San. Inst., 1910, 31: 33). That the NH_3-Cl_2 process results in sustained germicidal and algacidal effects seems to be undoubtedly due to formation of chloramines. Assumption that ammoniation increases the sterilizing efficiency of Cl_2 appears to be based on apparent rather than real facts. The compound, or compounds, formed on chlorination of water containing NH_3 depends upon ratio of NH_3 to Cl_2 and upon the pH value. When pH value is from 4.4 to 5.5, $NHCl_2$ is almost, if not wholly, the only compound formed. At pH 8.4, or higher, NH_2Cl only is produced. Between these values, varying proportions of the two are formed, depending on pH value, approximately equal amounts being present at pH 7. At pH values below 4.4, product is wholly NCl_3. When NH_2Cl has been formed lowering pH value will result in gradual conversion to $NHCl_2$. Available Cl in form of $NHCl_2$, however, is not materially less persistent than NH_2Cl and is more rapidly effective. This change is only partially reversible and loss of active Cl from $NHCl_2$ and NCl_3 occurs on addition of alkali. Extent of such loss in very dilute solutions, such as chlorinated water, has not been determined. Regardless of form of active Cl applied, rate of bacterial destruction is radically affected by changing pH value. Above pH 8.0, bactericidal action may be materially retarded, whereas lowering of pH value to less than 7.0 increases efficiency of a low residual Cl content very markedly. The residual Cl content in form of chloramine required for efficient disinfection varies considerably with changes in temperature. Several methods of preparing chloramine solutions, prior to application, are outlined and discussed briefly. To insure maximum chloramine production and minimum formation of NH_4Cl and other inert compounds in chlorination of sewage, it is essential that rapid distribution of Cl_2 throughout the sewage be effected. Recent evidence indicates that increased efficiency may be secured if Cl is applied in hypochlorite form, particularly when a moderate excess of alkali is added. The alkali temporarily raises the pH value at the point of application, thus encouraging the production of NH_2Cl from NH_3 naturally present in the sewage. The NH_2Cl formed is gradually converted into $NHCl_2$, the extent of this reaction being a function of the ultimate pH and the time of contact. During this period the effects of the active Cl persist, in many cases for hours. A practical method of producing alkali hypochlorite and at the same time vary-

ing the alkali and Cl_2 ratio to suit specific circumstances consists of applying an emulsion of lime and introducing Cl_2, preferably at several points, into the pipe line carrying the lime emulsion. Addn. of lime prior to application of Cl_2 has proven less satisfactory and more costly. Method outlined will be tried on large scale at two plants in near future. Bibliography of 11 references is appended.—*R. E. Thompson* (*Courtesy Chem. Abst.*).

Ventilation During Driving of New York's 20-Mile Water Tunnel. C. E. KELLEY and I. R. LOSS. Eng. News-Rec., **107**: 58–9, July 9, 1931. Brief details given of ventilation system being employed during construction of 20-mile tunnel No. 2 of New York water system, between Yonkers and Brooklyn. Entire project was let as single contract, totaling nearly $43,000,000. Sixteen headings are being driven from 19 shafts sunk to depth of 480 to 780 feet below ground surface. Short length of tunnel is roughly 20 feet in diameter inside rock line: remainder is 22 feet. Excavation is 85 percent completed. Air requirement for each shaft is about 7,000 cubic feet per minute. Plant consist of 15 sets of direct-motor-driven centrifugal compressors, or blowers, and 18 miles of pipe. It was found that after a blast tunnel could be cleared in least time by exhausting the air, smoke, dust, and gases for 1 hour, then reversing flow for remainder of cycle.—*R. E. Thompson.*

Blocking the Spillways of Dams is Dangerous. HOWARD K. BELL. Eng. News-Rec., **107**: 64, July 9, 1931. Danger of raising spillway level of earth fill dams is stressed. Flood conditions such as occurred in recent years would mean disaster to dams with partly closed spillways.—*R. E. Thompson.*

Successful Municipal Ownership in Huntingburg, Ind. GEO. RANDALL MCCORMACK. The American City, **45**: 6, 63–64, December, 1931. Huntingburg, Indiana, city of about 3,500 people, is good example of successful operation of municipally-owned heat, power, light, and water systems. Huntingburg is now free from debt, has money on deposit, and has a city tax rate of only $0.95 on $100. Its water supply is derived from three large artificial lakes and since the construction of last of these in 1927, supply is practically inexhaustible under ordinary conditions. System consists of two large reservoirs into which water is pumped from the lakes and from which it flows by gravity to city, giving a minimum pressure of 68 pounds. Minimum residential charge for water is $0.50 a month. Article also describes the electric power plant.—*Arthur P. Miller.*

The Business Operation of a Municipal Water Works. Anon. The American City. **45**: 5, 84–87, November, 1931. Waterbury, Conn., owns and operates its own water system. This article describes results of examination of methods followed in operation of the system conducted with view to strengthening provisions for financial management and to improvement of business administration. Questions of what water rates should cover, of making charges in proportion to costs, of payment for city-used water by department so using, of service charges, and of quantity charges are taken up. Important

function of furnishing water for fire protection and determination of annual charges on various bases are discussed.—*Arthur P. Miller.*

Meters Should Fit the Need, Not the Pipe. H. G. BROWN, JR. The American city, 45: 6, 82, December, 1931. Water meters are best installed of smallest size that will give discharging capacity actually required by taker. New Rochelle Water Company used to provide meters of same size as service pipes upon which they were set. This resulted in use of a number of meters too large for the work they had to do. By application of a load factor, as explained, from table, it was possible to cut down size of meters in use, which reduced capital investment. Rule now is that only in cases of actually proved necessity will meter as large as service pipe be permitted.—*Arthur P. Miller.*

Water Rates and Regulations. Anon. The American City, May, 1931, Part I, p. 139; June, Part II, p. 131; July, Part III, p. 144; August, Part IV, p. 124; September, Part V, p. 129; October, Part VI, p. 124; November, Part VII, p. 119. This long article, continued from month to month and completed in November issue, tabulates figures obtained from many cities on water meter rates, hydrant rentals, and sprinkler charges, and regulations for making taps and installation of service.—*Arthur P. Miller.*

Influence of different Concentrations of Hydrogen Ions and Temperatures of Water of Mosquito Larvae. HEM SINGLE PRUTHI. Indian Journal of Medical Research, 131–135, July, 1931. From Water and Water Engineering, 33: 398, 644, December 21, 1931. Observations on *Anopheles subpictus* show that hydrogen-ion concentration is reliable index to suitability of habitat of aquatic organisms, many of which flourish only in limited pH range. Although some larvae can live at high temperatures, few become pupae and adults. Some localities therefore may have mosquito larvae, but not adults which spread malaria. It is economical, before destroying larvae, to ascertain if the condition of the water will allow larvae to reach adult stage.—*W. G. Carey.*

Effect of Organic Substances on the Removal of Manganese from Water. B. A. ADAMS. Water and Water Engineering, 33: 397, 609–610, December 21, 1931. No organic compound was found to prevent absorption of manganese from aqueous solution by base-exchange materials, or to prevent its deposition on manganese permutit. Certain phenols, and phenolic and unsaturated acids prevented the precipitation of manganese by sodium carbonate, while some hydroxy- and ketonic acids and protective colloids caused precipitate to be very finely divided. Gluconic, saccharic, and mucic acids prevented precipitation of manganese with lime even with pH above 12, and some phenols and protective colloids caused a very finely divided precipitate. Unsaturated acids, hydroxy-polybasic acids, and some phenols interfered with manganese removal by potassium permanganate.—*W. G. Carey.*

Hoof Dams. A. M. A. STRUBEN. Water and Water Engineering, 33: 397, 611–617, December 21, 1931. Typical example is taken of hoof dam, consisting of series of thin stiffened buttresses which support a deck of thin

sloping arches on their upstream edges and a roadway on their tops, and details of design and calculations are given.—*W. G. Carey.*

Resistance Losses in Pipe Bends and Elbows. Anon. Water and Water Engineering, 33: 397, 605, December 21. 1931. In simple elbow of small angle, hydraulic resistance of rough pipe is 1.5 times that of smooth surfaced one, and is approximately proportional to the angle. In a large angle elbow, e.g. a right angle, the ratio of resistance decreases to 1.2. Resultant resistance of many elbows in series is considerably less than the sum of resistances in each. In a circular right angle bend, a most advantageous point from standpoint of hydraulics may exist in ratio of bending curvature to diameter of pipe. In a circular bend of an acute angle less than 22.5° the resistance is proportional to the angle.—*W. G. Carey.*

Rubble Dam with Central Screen. Revue Industrielle, September 1931, 497–511. Water and Water Engineering, 33: 396, 602, November 20, 1931. Rubble dams are sure and economic solution of water-retaining problem if different kinds of stone are available. The weak point is permeability, so that a screen is necessary. Dam in Tunis is mass of stones inside which an accessible impermeable armored concrete screen is buried. Retaining height is about 35 metres and length on crest 350 metres. Upstream side of screen is formed by juxtaposition of cylindrical arches with batter of 1:10 and span of 2.2 metres, thickness of arches varies from 10 to 25 centimetres, total width of screen being 2 metres at top and 9 metres at base.—*W. G. Carey.*

Some Disjointed Observations about Water Supplies. E. A. S. Fawcett. Water and Water Engineering, 33: 396, 576–578, November 20, 1931. Owing to increased water consumption, purification and sterilization will become more essential and river pollution will increase with growth of population. Author favors discharge of raw sewage into rivers provided volume of river sufficient for adequate sewage dilution. Efficient gauging of rivers should be encouraged, because no universal method of assessing compensation water can be laid down until river flow records have become generally available. Reservoir safety provision Act was urgently needed; but one panel of engineers both to design and to inspect reservoirs would be preferable to two panels now existing. Present road alterations accentuate difficulties of water engineers, either by inadequate cover, or by deep burying of mains, and it is unsatisfactory that legally water undertakings cannot claim from road authorities for extra expense involved.—*W. G. Carey.*

Aubrey Street Pumping Station, Liverpool (England) Corporation Water Works. J. R. Davidson. Water and Water Engineering, 33: 396, 563–571, November 20, 1931. Water demands in district supplied by high level tank having risen from 1 to 5 million gallons (Imp.) since 1857, three separate electrically-driven centrifugal pumps have been installed, two of which deal with peak day load of 270,000 gallons (Imp.) per hour, third being standby. Diagrams show how building originally erected to accommodate Cornish bean engine has been adapted; false ceiling reduces excessive height and appear-

ance of length is disguised by new entrance hall. Work was carried out in stages to allow standby for existing vertical triple expansion rotative engine of 300,000 gallons (Imp.) which is still to be kept in reserve. Pumps are automatically controlled from high level tank by three float relay switches operating at different water levels, and automatic control board is installed, as well as overload release, time delay relay, phase balance relay, and thermostatic control for pump bearings.—*W. G. Carey.*

Concrete Water Towers and Leakage. Anon. British Waterworks Official Circular, **13**: 95, 588, August, 1931. Concrete water towers should be treated inside with cement rendering as defence against leakage. Concrete less rich than 1: 1½: 3 should not be used and reinforcement should be symmetrically disposed and in such manner as not to neglect stresses of shrinkage and of temperature variation, an important factor being stresses set up when one side is exposed to direct sun and the other remains cool.—*W. G. Carey.*

Reservoir Pollution by Seagulls. Anon. British Waterworks Official Circular, **13**: 95, 583, August, 1931. Estimates in Dundee show that 100 gulls will so contaminate reservoir holding 100 million gallons (Imp.) of water, that samples will give positive *B. coli* reaction in 40 cc. Wiring of open reservoirs was found to be effectual remedy at Belfast. Sir ALEXANDER HOUSTON estimates that each gull may contribute 50–100 million *B. coli* per day to water supply.—*W. G. Carey.*

Swimming Pool Filtration. Anon. British Water Works Official Circular, **13**: 95, 576, August, 1931. Minister of Health states that method of continuous rapid filtration combined with continuous chlorination and aëration keeps water clear, sparkling, attractive, and bacteriologically pure and is economical. This method has advantages over fill-and-empty system even when refilling done daily and advantages are overwhelming when filling is less frequent.—*W. G. Carey.*

Water Supply and Purification During 1931. A Review. NORMAN J. HOWARD. Water Works and Sewerage, **79**: 1–5, 1932. Discussions of new works and extensions, coagulation, filtration, corrosion problems, water softening, chlorination, super and de-chlorination, activated carbon, and oligodynamic sterilization.—*C. C. Ruchhoft.*

Metering: Practical Methods of Procedure. E. H. RUEHL. Water Works and Sewerage, **79**: 19–21, 1932. Discussion of advantages of metering; of ownership and location of meters; and of installation.—*C. C. Ruchhoft.*

The Santiago, Cuba, Water Supply. JOHN F. PIERCE. Water Works and Sewerage, **78**: 351–4, 1931. Latest accepted plan provides for construction of concrete dam on River Cauto to impound 7,000,000 cubic meters [5600 acre-feet]. From here water will flow through 48-inch concrete pipe to another dam at Reposo. Series of tunnels and 60-inch pipe will carry the water further to proposed dam at Corta Calenturas. From this dam, 60-inch pipe will

convey the water to Quinteron Hill, near Santiago, where filter plant will be constructed.—*C. C. Ruchhoft (Courtesy Chem. Abst.).*

The Use of Charcoal and Activated Carbon in Water Treatment. JOHN R. BAYLIS. Water Works and Sewerage, **79**: 14–17, 1932. Only two municipal water supplies have beds of activated carbon for taste and odor removal. They are at Bay City and Dundee, Mich. An experimental unit at the Chicago Experimental Filtration Plant has been in use for three years and 65,000 gallons of water per pound of carbon has passed through the bed. Powdered activated carbon is most extensively used and may be applied to the coagulant mixing chamber through chemical dry feed machine with ejector discharge.—*C. C. Ruchhoft (Courtesy Chem. Abst.).*

Water Consumption During Fires. C. W. MOWRY. Public Works, **62**: 10, 20–1, 1931. The sooner the water is applied, the less water is required to extinguish a fire. Sufficient water must be provided to fight any fire which nature and size of city makes possible. Less than 1 percent of annual water consumption is used to fight fires. Tables are given showing rates of flow needed for various populations, and rates and amounts of water actually used at various large cities.—*C. C. Ruchhoft.*

The Use of Charcoal and Activated Carbon in Water Treatment. JOHN R. BAYLISS. Water Works and Sewerage, **78**: 357–362, 1931. Very small amounts of dissolved organic substances may cause objectionable tastes. The adsorption of such noxious material by activated carbon involves complicated chemical problems, many of which are not clearly understood. Practically all organic compounds are adsorbed by activated carbon, as also are, to a certain extent, many inorganic substances. Sulphates of alkali metals, glycocoll, and certain alkaloids are said not to be adsorbed. Not only are offensive compounds taken up, but inoffensive compounds, which predominate in most waters, are also adsorbed; which tends to exhaust activated carbon very rapidly. The adsorption of non-electrolytes is very good evidence that adsorption by active carbon is not ionic. MILLER and others have extensively studied reactions of active carbon with many organic and inorganic substances. Fatty acids are adsorbed at rate increasing directly as number of carbon atoms is increased. Quantity of a compound adsorbed increases, in proportion as surface tension of solution becomes diminished by increasing concentration. With exception of chlorinous taste, nearly all taste-producing compounds likely to occur in water are organic and can readily be adsorbed. Most of these organic compounds are present in such small amounts that they cannot be detected by ordinary tests. Chlorine reacts with water to form HOCl and HCl: HOCl oxidizes the carbon to CO_2. Following formulation summarizes the reactions which take place:—$2Cl_2 + 2H_2O + C = 4HCl + CO_2$. Molasses and phenol tests for adsorption capacity of carbon are described.—*C. C. Ruchhoft (Courtesy Chem. Abst.).*

Manganese in Filters. LEWIS V. CARPENTER. Water Works Engineering, **85**: 136, February 10, 1932. Manganese causes rusty stains on plumbing

fixtures and brown discoloration on clothing and linens in the laundry. Appearance of manganese in surface water supplies of northern West Virginia has been closely allied with development of bituminous coal mining and subsequent acid drainage entering the streams. Analysis of typical coals shows only minute quantities of manganese carried therein. It is possible that acidity of the water may have something to do with solution of manganese from shales surrounding the coal. Filter sands of plants at Weston, Clarksburg, and Morgantown, West Virginia, have apparently been increased in effective size and blackened. "Chlorination of the raw water in doses as great as 5 p.p.m. does not oxidize the manganese. Laboratory as well as plant tests indicate that lime in sufficient quantities to remove the CO_2 and bring the pH value above 8 will cause the manganese to be precipitated." Presence of manganese interferes with interpretation of ortho-tolidine reaction for control of chlorination, but seems to have little effect upon efficiency of filtration. —*R. L. McNamee.*

Tests of Integral and Surface Waterproofings for Concrete. C. H. JUMPER. U. S. Department of Commerce, Bureau of Standards, Journal of Research, 7: 6, 1147, December, 1931. This paper is a report of the study of fifty commercial integral and fifty surface waterproofing materials for concrete. The integral materials were incorporated into a 1: 3: 6 concrete and subjected to a water pressure of 20 pounds per square inch for one year and their permeability noted in comparison with plain concrete of the same quality tested in a similar manner. The surface waterproofing materials were applied to 3 by 6 inch concrete cylinders and their absorption determined, after immersion in water, at regular intervals up to one year. These results were compared with the absorption figures obtained on uncoated concrete given the same treatment. These tests of which the complete procedure is presented, indicate among other things: the autogenous sealing up of the slightly leaking concrete seems to be quite an effective means of obtaining water tightness and this condition seems to result as readily when no waterproofing agent is present as when one is; the simpler materials, such as stearates, which can be bought in open competitive markets without paying for trade names, are as effective as any; calcium chloride is still the most used under striking names and camouflaged through the use of dyes; the coatings composed largely of inorganic pastes, such as iron oxide, cement, etc., gave poor results according to the test procedure used due to there being enough finer pores to permit of sufficient capillarity to give a high absorption. Some of the transparent coatings such as linseed and China wood (tung) oil gave good results. In the case of leakage due to cracks following settlement or shrinkage, the use of coatings tending to seal over autogenously should be considered in preference to others not having this property.—*A. W. Blohm.*

Feed-Water Flow Controlled by Steam Flow. Ind. Eng. Chem., News Edition, 10: 23, 1932. Description of recent development for general use in steam generation.—*Edw. S. Hopkins.*

New Apparatus for Sampling of Water. A. JENDRASSIK and K. BOLBERITZ. Ind. Eng. Chem., News Edition, 10: 54, 1932; cf. Magyar Chem. Folyoirat,

38:11–5, 1932. Apparatus is about 3 inches in diameter and was developed for sampling of mineral waters at desired depths to retain gas content of water. It is applicable for use in deep artesian wells. [In so far as known this apparatus has not been used in this country as yet.—ABSTR.]—*Edw. S. Hopkins.*

Prevention of Corrosion of Metals by Sodium Dichromate as Affected by Salt Concentrations and Temperature. B. E. ROETHELI and G. L. COX. Ind. Eng. Chem., 23: 1084–90, 1931. Soluble chromates added to distilled water in concentrations varying from 0.1 to 0.4 percent will protect from corrosion iron and steel immersed therein. This material will also protect these metals in salt solutions up to boiling point at any concentration of sodium chloride. Aluminium is also protected at room temperature in dilute salt solutions, while copper, brass, lead, zinc, and galvanized iron are partially so. Degree of protection under conditions of actual use is governed by chromate concentration.—*Edw. S. Hopkins.*

Some Factors Influencing Soap Tests for Hardness. R. H. KEAN and H. GUSTAFSON. Ind. Eng. Chem. (Analytical Ed.) 3: 355–6, 1931. Authors are especially concerned with testing of zeolite-softened waters. Temperature is shown to be a factor, causing slightly high results at under 10°C. Free carbon dioxide is a disturbing factor, due apparently to its effect upon pH values. This is particularly true for waters of low alkalinity. For plant control, when this test is made daily, conditions presented are not of especial concern. For controlling individual softeners, they must be considered; particularly with heated waters, as used in laundries.—*Edw. S. Hopkins.*

Volumetric Barium Chromate Method for Sulfates. J. R. ANDREWS. Ind. Eng. Chem. (Analyt. Ed.) 3: 361–2, 1931. An accurate method is presented, based upon HINMAN'S older procedure, and suitable for sulfate concentrations between 2 and 200 p.p.m. It was developed particularly for oil well waters, but is generally applicable.—*Edw. S. Hopkins.*

Experiences in the Sphere of Drinking Water Purification. E. LINK. Gas- und Wasserfach, 74: 38, 877–885, September 19, 1931. Presented at meeting of Deutscher Verein von Gas-und Wasserfachmännern, June, 1931. Chlorine diagram (A.D.M.) of water is curve obtained by plotting as abscissae varying amounts of chlorine added to water at a definite temperature, and as ordinates, percentage of chlorine consumed as determined by residual chlorine after 30 minutes contact with water. Form of curve so obtained is sufficiently characteristic of purity of water without further resort to chemical, or bacteriological, methods. Experience in use of A.D.M. process for one year at Berg Neckar waterworks, Stuttgart, has shown value of such diagrams, from inspection of which it is possible to classify waters into three groups. Group 1 comprises pure waters, free from organic, or other, chlorine consuming constituents, with permanganate consumption of, at most, 5 parts [oxygen consumed 1.27 parts] per million and chlorine number of, at most, 2 parts per million. Group 2 are less pure, with permanganate figure of 5 to 15 [oxygen consumed, 1–27 to 3.80] and chlorine number of 2 to 5 parts per million, and

give a different form of curve. Group 3 and its sub-group contain highly polluted waters having permanganate consumption and chlorine number higher than above. Series of diagrams given by same waters at different temperatures are given, illustrating division into groups, and are discussed in detail. Amount of chlorine to be added in practice is obtained from 25°C. diagram, allowing 20 percent residual chlorine. After "diachlor" treatment, so named because chlorine dosage is calculated from diagram, Stuttgart water is treated in "Mutonator," i.e. vessels containing active carbon in which adsorption and oxidation occur. Experiments on removal of phenol by this apparatus are described and methods of regenerating carbon monthly with alkaline hypochlorite solution. Details of Berg Neckar water purification are given; raw Neckar water is prechlorinated, clarified by precipitants and settlement, again chlorinated, filtered through rapid and slow filters, and passed through "Mutonator." Resulting water contains no residual chlorine, and is free from phenol, odor, taste, and color. Raw Neckar water contains 18,000 colonies per cubic centimeter, with *B. coli* present, purified water contains 0 to 5 colonies per cubic centimeter at 46°C. or at 37°C. Charts are given showing that mortality, infant mortality, and incidence of typhoid alike exhibit marked reduction since water treatment in force.—*W. G. Carey.*

Modern Water Supply and Hygiene. ABEL. Gas-und Wasserfach, **74**: 37, 849–857, September 12, 1931. General discussion of water supply in Germany from health standpoint. Water is an indispensable food, and it is important that it should be pure in origin, and appetizing. Treatment of surface water and growing preference in Germany for ground water, artificial ground water, bank filtered water, and impounded water are discussed. A.D.M. process at Stuttgart, using superchlorination with known amount of residual chlorine, is mentioned. Rivers grossly polluted can yield chemically pure, hygienic, and tasteless water, but slow natural processes of purification are very different to rapid processes of water treatment. Germany is well supplied with ground water and such water, even at higher cost, is preferable to that from polluted sources. In Berlin, consumption per head has risen from 108 litres per day in 1922 to 149 litres in 1929. Some 90 percent of water is not used for drinking or hygienic uses, but separate supplies to houses for drinking and for industrial purposes is impossible in practice.—*W. G. Carey.*

Use of Active Carbon in Drinking Water Supply and Waste Water Treatment. F. SIERP. Gas-und Wasserfach, **74**: 33, 764–774, August 15, 1931. Paper read at meeting of Deutscher Verein von Gas-und Wasserfachmännern, June 1931. Information is given concerning production of active carbon from lignite, peat, etc., methods of obtaining high porosity, properties, testing, and methods of application and of reactivation. In removal of excess chlorine and phenol from drinking water, chlorine is converted in pores of carbon into hydrochloric acid with liberation of oxygen from water, hydrochloric acid is neutralized by carbonate in water so that no alteration in pH value is caused, while nascent oxygen combines with organic matter. Phenol is adsorbed as such, or as chlorphenol, and experiments in connection with Hamm (Germany) water, which has phenol content ranging from 0 to 20 parts per million, show

that granular carbon (of 2 millimeters diameter) adsorbs about 1 percent of its weight of phenol and allied bodies, and that it can be regenerated with steam; but water should be purified as far as possible by other methods, to obviate too frequent reactivation. Various active carbon installations are referred to and filter at Hamm water works is described. Application of activated carbon to water—sewage—water cycle is dealt with and proposed sewage reclamation scheme for Los Angeles is mentioned. Use of activated carbon in purification of trade waste waters and of swimming bath water is referred to, and since in Rhine-Westphalian Industrial area 90 percent of water supplied is for industrial purposes, it is advocated that carbon filtration for remaining 10 percent should be performed individually in small house filters, which are described and illustrated.—*W. G. Carey.*

New Process for the De-acidification of Water. J. TILLMANS, P. HIRSCH and H. LÜRMAN. Gas-und Wasserfach, **74**: 48, 1097–1101, November 28, 1931; 49, 1128–1133, December 5, 1931; 50, 1147–1149, December 12, 1931; 51, 1172–1175, December 19, 1931; 52, 1195–1198, December 26, 1931. Free carbon dioxide cannot be removed from water by calcium carbonate if much calcium bicarbonate is present. Theoretically, magnesium carbonate is more efficient, but natural dolomite or magnesite has only slow action with carbon dioxide in solution. Magnesium oxide, formed by igniting magnesite, reacts readily, does not lose its granular structure, and removes free carbon dioxide, so that the water is no longer aggressive, the magnesium oxide adsorbing 20 to 30 percent of its weight. Excessive water feed reduces efficiency owing to surface absorption of carbon dioxide, too small feed also reduces efficiency owing to deposit of lime on filter material, filter therefore cannot produce greater alkalinity than equivalence of lime and carbon dioxide. Addition of lime water or soda to water suffers from drawback that alkaline water may be obtained by overdosing, or treatment may be insufficient; aeration and calcium carbonate treatment are also inefficient. Experiments in small filters and on large scale over period of many months show process satisfactory and applicable to hard or soft corrosive waters, and iron is absent from treated water.—*W. G. Carey.*

Seasonal Manganese in a Public Water Supply. EDW. S. HOPKINS and GEORGE B. MCCALL. Ind. Eng. Chem., **24**: 106–8, 1932. Stored water containing carbon dioxide may leach manganese from underlying soil. Fermentation of organic material left on sides and bottom of unstripped reservoir will furnish carbon dioxide. Autumn turnover will then distribute manganese through the water and it may by aeration be converted into an unstable hydrated oxide. Decomposition of dead microörganisms does not affect this condition materially. Hence copper sulfate treatment is effective to control taste and odor only. Rentability of stripping a reservoir for manganese control depends upon how cost of the work compares with cost of applying iron and lime coagulation for a few years.—*Edw. S. Hopkins* (*Courtesy Chem. Abst.*).

Titrimetric Determination of the Alkali Metals in Water. J. TILLMANS and E. NEU. Zeitsch. für Untersuchung der Lebensmittel, 1931, **62**: 5, 593-

596. When measured volume of water is taken to dryness with a few cubic centimeters of sulphuric acid, dissolved salts are all converted to sulphates and organic matter present is destroyed. When redissolved sulphates are treated with baryta water, all bases but alkalis (and a little lime) are precipitated as hydroxides and sulphate as barium sulphate. Carbon dioxide will now precipitate baryta and lime as carbonate and alkali metal carbonates remain in solution and may be titrated. Complete precipitation of earths is ensured by adding known amount of sodium carbonate. Suitable quantity (50 to 1000 cc.) of water is acidified with 10 drops concentrated sulphuric acid and taken to dryness on water bath in platinum dish. Alternatively, the dry residue may be moistened with concentrated sulphuric acid. Excess acid is gently fumed off. Residue is taken up with hot water and quantitatively transferred to measuring flask. Heat to boil, and add dropwise as boiling begins slight excess of baryta water. Allow to settle, cool, make up to mark, shake well, and filter. Filtrate is at first clear: later, barium carbonate turbidity occurs. An aliquot (75 to 90 percent) of filtrate is treated with phenolphthalein and carbon dioxide is led in until pink color just disappears. Evaporate down until pink returns and complete precipitation by adding dropwise 20 cc. 0.1 N sodium carbonate. Cool, filter rapidly with suction, wash beaker and precipitate with small quantity (20 to 25 cc.) cold carbon-dioxide-free water and titrate with 0.1 N hydrochloric acid in presence of methyl orange. Recovery of sodium chloride from prepared waters to which known weights had been added was practically quantitative. Agreement with gravimetric results upon natural waters was somewhat less close, which may have been due in part to presence of potassium in appreciable amounts, in part to error inherent in the long and troublesome gravimetric method. Cf. MALJAROW, Mikrochemie, **8**: 63–71, 1930; also SAZ, Ann. Chim. Anal. Appl. 1929 [3] **11**: 289 and Zeitsch. analyt. Chem., 1930, **82**: 192.—*Frank Hannan.*

NEW BOOKS

Vom Wasser, Ein Jahrbuch für Wasserchemie und Wasserreinigungstechnik. V. Band: 1931. 268 pp. Verlag Chemie, G. M. B. H., Berlin W. 10. (Selected Papers.) **Experiences in Deacidification with Calcium Hydroxide.** W. STEFFENS. 11–18. If lime saturators are not fitted with stirrers and if hopper of wrong shape, then incompletely saturated lime water will result with small flow velocities; if saturators are too small, turbid lime water results, because upward velocity of water in saturator exceeds settling velocity of lime particles. If lime water dosage is controlled by Venturi tube, wide fluctuations in rate of flow may create disturbing effect. Valuation of lime used is advocated. Samples of treated water should be taken at sufficient distance from point of lime water addition to allow reaction to complete itself. **New Experiences in Sterilization of Water with Chlorine and Chlorine Compounds.** T. FOLPMERS. 62–83. System of automatic chlorination at Rotterdam water works by Wallace and Tiernan apparatus is described and illustrated. Chlorination experiments on BUNAU-VARILLA agitation system show that in absence of ammonia its advantages are very great, owing, no doubt, to improved chances of contact between bacteria and unchanged chlorine. Differing specific

reaction velocities of chlorine with bacteria and with various forms of organic [and inorganic] matter present has certain effect; under certain conditions, less chlorine than is indicated by chlorine demand effects sterilization. Experiments were made with chloramine and reproductions of plate cultures for varying times of chloramine treatment are given. Chloramine is not so efficient as chlorine, or hypochlorite, unless the time of contact is adequate, but is advantageous in some instances because with chloramine it is unnecessary to bring the bacteria into contact therewith very rapidly. Table is given of initial dose of chlorine required to destroy *B. coli*, *B. aërogenes*, *B. subtilis*, and other organisms in from 30 to 60 seconds. **Investigation of Activated Carbons for Water Purification.** M. JAENICKE. 83–92. Evaluation of carbon for water purification should include determinations of adsorptive power; dechlorinating power; hardness; particle size; loss in sieve analysis; and resistance to filtration. Methods for these determinations are described in detail and tables are given showing results obtained with various grades of Hydraffin carbon. Exact research methods for problems concerning use of active carbon in water purification are as yet incomplete; most methods adopt higher concentrations than obtain in water treatment. **Contributions to Knowledge of Waters Containing Iron and Manganese, and of Aggressive Waters.** F. EGGER. 46–52. Water originally containing organically combined iron to extent of 26 p.p.m. and 0.6 p.p.m. manganese after treatment with natural black manganese sand contained only 0.2 p.p.m. iron, while manganese was undetectable. Artificial black sand cannot be recommended. Alterations in soil in neighborhood of water containing iron should be noted, as iron content may be influenced by changes in soil. With aggressive iron-containing waters, closed iron removal plants are frequently unreliable. Corrosion occurred in hot water system with non-aggressive water of high bicarbonate content, owing to liberation of carbon dioxide. **Removal of Manganese from Moorland Water.** G. NACHTIGALL. 56–62. Moorland water with pH of 6.75, and ferrous iron 16, manganese 2.8, free carbon dioxide 120, and ammonium ion 6, parts per million, was treated in experimental plant by aëration and filtration through coarse and fine filters with addition of lime water. Lime water promoted manganese removal by neutralization of acidity in manganese filter, but was added after iron removal, as otherwise iron hydroxide precipitate was too finely divided for filtration. Manganese removal gradually decreased, owing to oxygen consumption on filter. Increased aëration of water to manganese filter caused further oxygen consumption and nitrification of ammonium ions at expense of manganese removal; but treatment with potassium permanganate regenerated and sterilized the filter. **Phosphate Treatment of Boiler Feed Water and Boiler Water.** A. SPLITTGERBER. 93–108. Practical experience of addition of trisodium phosphate to boiler water has given generally favorable results in plant operation as scale preventive, but it cannot be recommended as exclusive softening material. For prevention of foaming and priming, hardness of water should be reduced as far as possible before addition of phosphate. Corrosive action of phosphate is very slight and boiler plates do not suffer. Phosphate as scale loosener is not successful in all cases and is more so in ships' boilers than in stationary boilers. Phosphate does not seem to be suitable as substitute for, or supple-

ment to, sulphate in medium or high pressure boilers as preventive of boiler plate embrittlement. Phosphate may be made in boiler house from phosphoric acid and caustic soda, or, with strongly alkaline feed water, phosphoric acid may be added thereto. Author states that this has been practised in America for many years. To ascertain phosphate content of feed water, a colorimetric method has been devised which depends on blue color produced by phosphate and sulpho-molybdate in presence of tin dichloride. **Modern Experience of Boiler Scale Prevention with Trisodium Phosphate.** P. KOEPPEL. 108–124. Trisodium phosphate completely eliminates hardness, precipitating tricalcium and trimagnesium phosphates, and in shorter reaction time (1 hour at 70°C.) than other softening reagents. Complete treatment in softener is unnecessary, as slight excess of phosphate in feed water precipitates calcium, magnesium, and iron as powdery floc in boiler and loosens existing scale by base exchange. No silicate scale is formed, as silica forms soluble sodium salt. Oil is separated in precipitate and no corrosion occurs. Boilers can be operated at lower alkalinity when using phosphate. Rapid test for boiler house operation for excess of phosphate is described, precipitating as phosphomolybdate, and observing time required for appearance of yellow precipitate. Long **discussion** follows. **Softening with Phosphate** K. SCHILLING. 124–134. In lime-soda softening, chemicals must be added exactly according to composition of raw water and, for low residual hardness, excess chemicals are necessary, which cause trouble in boiler; as also does larger residual hardness. Phosphate softening requires only one chemical and incorrect amount, due to water variation, adjusts itself in boiler; while excess phosphate dissolves old scale. Calcium and magnesium phosphates are flocculent, so that scale formation is eliminated. Satisfactory phosphate softening was obtained at first at Frankfurt, Germany, electricity works, but after some time large residual hardness was noted, even with excess phosphate, and it was found to be necessary to add alkali sufficient to ensure formation of insoluble di- and tri-alkaline earth phosphates, mono- salts being soluble. Titration process, depending upon action of the three phosphates on methyl orange and phenolphthalein, is described as being sufficiently accurate for boiler purposes. Cost of phosphate softening is somewhat higher than lime-soda, but compensation is found in freedom from scale and in wide latitude allowable for variation in raw water addition and composition. **Determination of Hardness in Water.** J. LEICK. 171–177. CLARK's method of hardness estimation gives with hard water accuracy of ± 0.05 millivals [2.5 p.p.m.; 1 millival equals 50 p.p.m.] and, with low hardness, accuracy of ± 0.1 to 0.15 millivals [5 to 7.5 p.p.m.]. For low hardness, MOHR's modification, in which free alkali in excess of pH 9 is first removed, gives better results. Methods of BOUTRON and BOUDET and of WARTHA-PFEIFFER give low results. BLACHER's titration method is generally recognized as best and tests of its accuracy with calcium and magnesium chlorides and sulphates were made, using N/10 and N/28 solutions of potassium palmitate. Additions of 5 percent of sodium chloride, or sulphate, caused high results; but, with hardness below 15 to 20 millivals [750 to 1000 p.p.m.], within limits of experimental error. For determination of magnesium separately, BLACHER's method of first precipitating lime as oxalate and then titrating magnesia with palmitate is ad-

vocated. Various modifications of lime and magnesia determinations to test these results were tried and methods adopted were to precipitate lime as oxalate and titrate with permanganate, and to precipitate magnesia with sodium phosphate, drive off ammonia by heating at 50–70°, dissolve precipitate in excess of N/10 sulphuric acid, and determine excess of acid by titration with alkali. Precipitation of magnesia with 8-hydroxy-quinoline shortens the process.—*W. G. Carey.*

Experiments of the Water and Sewage Purification Committee, Madras, on the Treatment of a Stored Tropical Water. H. H. King, T. N. S. Raghavachari and K. V. Narasimha Ayyangar. 6 pp. 1931. Presented before Conference of Far Eastern Association of Tropical Medicine in 1930. Summarizes experimental work carried out during past 15 years in connection with purification of Madras water supply. Impounded water from Korteliar River, which has drainage area of 940 square miles, flows into Cholavaram reservoir and thence into much larger reservoir known as Red Hills Lake. These reservoirs, with total capacity of 2,200 million cubic feet, have catchment area of 34 square miles. Rainfall is almost entirely confined to period June to December, and storage is therefore required for at least 6 months and, in addition, for poor monsoons. From Red Hills Lake water flows through 7-mile, underground conduit to works at Kilpauk, which consist of 17 slow sand filters. Effluents are collected in underground reservoirs and pumped either to city, or to balancing tank. When built, in 1914, each filter had 28-inch topmost layer of sand passing 10-mesh and retained on 40-mesh screen. Filters are now operated at rate of 6 inches vertical per hour [3.9 m.g.a.d. U.S.], rate having been increased from 4 inches vertical [2.6 m.g.a.d. U.S.] two years ago to meet increased demand for water. Soon after filters were placed in commission it was found that efficiency, while generally good, was variable, and that during warmer months, March to October, hydrogen sulfide was produced in considerable quantities both in filters and in distribution system, particularly in outlying sections, filaments of *Crenothrix* and small brown masses of vegetable débris being common in distributed water. Total solids content of raw water varies between 110 and 300 p.p.m., SO_3 content being 10 p.p.m. Formation of iron sulfide in filter sand indicated that hydrogen sulfide production occurred from point 4 inches below surface downward. It is believed that hydrogen sulfide trouble is due to high organic content of water, which is derived from surface washings, and to development of microscopic organisms during storage. Hydrogen sulfide content of filter effluent is reduced during pumping and storage, but again increases in distribution system. Due to high organic content, filter runs are only 10–15 days. Covering the filters does not prolong the runs. Since 1926, water has been chlorinated 5 to 20 minutes prior to filtration (from 0.8 to 1.6 p.p.m.); this has resulted in 25 percent reduction in filter cleanings. Chlorination of filter effluent is impracticable owing to hydrogen sulfide content. Chlorine applied at inlet to raw water conduit over period of about one year resulted in slight reduction in bryozoal growths in conduit. Vibrios have often been found in raw, filtered, and distributed waters, but their presence does not appear to have been in any way connected with incidence of cholera in city. They do not agglutinate with high-titer cholera anti-serum

and do not appear to be of true cholera type. Conclusions formed by number of investigators who have reported on supply are outlined. Studies have been carried out by Government Water and Sewage Purification Committee since 1922, and in 1927 experimental station was constructed at which mechanical, slow sand, and percolating filters have been compared. Experiments showed that slow sand filtration was the least efficient, both bacteriologically and chemically; hydrogen sulfide was present in effluent during greater part of year. Mechanical filtration, without prior coagulation, was not satisfactory. Coagulation with alum, and mechanical filtration with subsequent slow sand filtration produced excellent effluent except for presence of hydrogen sulfide during certain months. Pre-filtration through percolating filter at rate of 24 inches vertical per hour [15.5 m.g.a.d. U.S.] and secondary slow sand filtration at rate of 8 inches vertical per hour [5.2. m.g.a.d. U.S.], or double the normal rate, yielded excellent effluent, practically always free from hydrogen sulfide, reduction in organic content being greater with this than with any other procedure experimented with. Percolating filters were similar in construction to slow sand filters, but with topmost layer of 3 feet of gravel, 0.1 to 0.25 inches in size. It was found that after long first run of several months (6 months in 1 case), these filters had tendency to pond after runs of about one month and had to be cleaned by removing 3 to 6 inches of topmost layer, or by spading and hosing to depth of 12 inches. Substituting 3 feet of broken granite, 0.25 to 0.75 inch in size, for fine gravel delayed ponding slightly, but organic matter removal was lower. During one period when organic content of raw water was higher than usual, hydrogen sulfide appeared in effluent after 9 months' operation, but in only one-tenth the amount appearing in the control slow sand filter. This occurrence was taken as indication that percolating filters were being overworked, and rate has since been reduced to 16 inches vertical per hour [10.3 m.g.a.d. U.S.]. Dissolved oxygen content increased in passage through percolating filters during first few months of operation, but decreased as filter became dirty. There was also further decrease in secondary submerged sand filters, but less than in control slow sand filter. On centrifuging 16 samples of raw water with average organic content of 1.68 p.p.m., average of 1.31 p.p.m. was found to remain in supernatant while average of 0.37 p.p.m. was deposited. It is suggested that such separation of mainly organized from mainly unorganized organic matter may prove of value in study of water supplies. Similar experiments on filter effluents showed that practically no reduction in that portion of organic matter which is not deposited on centrifuging is effected by slow sand filtration and only very little in percolating filters. Absence of nitrate in percolator effluents also indicates that purification effected is mainly mechanical and not biological. Trouble with slow sand filters is also experienced at several other plants in India. Percolating filters have been employed in parallel with slow sand filters during past 20 years at Bedford, England, where they are operated intermittently and appear to be as effective as the submerged filters.—*R. E. Thompson.*

Ohio Public Utility Rate Book. Part I. Water Rates and Service. ELLSWORTH WOLFSPERGER AND REX N. JOHNSON. The Ohio Municipal League,

Ohio State University, Columbus, Ohio, November 30, 1931, 47 pages, $3.00. It is the plan of the Ohio Municipal League to prepare and publish comparative data on rates and service in Ohio cities for water, electricity, gas, telephone, heat, and street railway utilities. The present volume is a result of the study of the water systems only. Data from all of Ohio's 110 cities and from many of the larger villages are given. These data are listed under the following headings: Ownership and Construction; Source and Treatment; Meters; Pumping; Water Connections; Hydrants; Sewage; Rates, and Finance.—*A. W. Blohm.*

Lake Michigan Sanitation Congress, Proceedings of Second Annual Meeting, St. Joseph, Michigan, December 11-12, 1925. 108 pages. **Report of the President.** HENRY W. LEE. 5–6. **The Protection of Chicago's Water Supply.** CHAS. B. BURDICK. 7–19. Separation of domestic wastes from drinking water constitutes great problem in city development, especially to those located on shores of Great Lakes, since latter must usually serve alike as source of water supply and as recipient for sewage discharge. Although Chicago diverts her sewage from the lake, certain existing sources of pollution will continue seriously to menace her water supply unless adequate precautions are taken. Distances from mouths of Chicago and Calumet Rivers to Chicago intakes are given. Towns between Highland Park and Waukegan discharge raw sewage into lake. Grand Calumet River is the main sewer for region of Indiana Cities east of Illinois State line, including Gary. Considerable sewage from shore population in Hammond and Whiting and wastes from several industries discharge directly into lake. Sewage systems of Gary, East Chicago, and Hammond drain inland, only reaching lake through outlets of the Calumet. Hydrographic description and relationship of the Grand and Little Calumet Rivers, Lake Calumet, and Sag Channel are given. Water level changes in the Calumet Rivers and Lake caused by flood and wind action are described. With prevailing rates of flow in the drainage canal, there is little danger of pollution from the Chicago River; but with reduced rate of flow, this danger increases. Investigations show that lake water quality at any point reasonably distant from shore, varies from sterility at one time to gross pollution at another, depending on wind action. Turbidity is also a wind function. On-shore winds cause under-tow, with high turbidities. All objections to present Chicago water supply can be eliminated by filtration at moderate expense. Ohio River cities successfully treat very polluted water. Tables presented show drop in typhoid death rates in other cities coincident with beginning of filtration. Filtration is only adequate safe-guard for Chicago supply, regardless of sewage treatment and diversion. Three tables and two charts given. **Health and Happiness in Indiana.** WM. F. KING. 20–22. Gives death rates caused by certain diseases in Indiana from 1915 to 1924. the related economics in man value, and the function and accomplishments of State Department of Health. **Methods of Sewage Disposal and Water Treatment Applicable to Lake Michigan Municipalities.** GEORGE W. FULLER. 23–32. Lake Michigan will not be cleaned of its growing pollution until earnest and practical coöperative effort by each community represented in the Congress brings about suitable remedial works. Resulting from expected enormous

increase in commerce and population, task of getting suitable water supplies from southern end of Lake Michigan will present difficulties appreciated now only by few. Essential steps of working program in interests of public health are as follows. (1) Comprehensive plans for interception of flow of existing sewers and for pumping, if necessary, to suitable sites for treatment. (2) Comprehensive plans for extending existing sewer systems to facilitate (1). (3) Rigid adoption of such plans, with all future works to be built in conformity therewith. (4) Selection of appropriate method for preliminary sewage treatment, by fine screening, or by sedimentation; with plans for locating and installing works at suitable sites for present, or future, needs. (5) Plans for sterilizing sewage, if required, at times, to supplement preliminary treatment. (6) Selection, plans included, of finishing treatment, either filters, or activated sludge, if same should be required at times to oxidize organic matter, when volume of sewage would otherwise over-tax reasonable use of the dilution method of disposal. (7) Elimination or adequate treatment at the source, of trade wastes. (8) Establishment of administrative authority, clothed with full powers to carry out all necessary works. (9) Establishment of reasonable program for financing construction of necessary works; development of public opinion to point where such expenses will be recognized as necessary part of budget of public expenditures, as now are schools, hospitals, etc. (10) Adoption of effective program for filtration, or sterilization, when and as required, so as to provide all municipalities at all times with safe, attractive looking, palatable water; for elimination of water waste; and for establishment of equitable rates. (11) Adoption of suitable program for financing the efficient operation of sewage purification and water purification plants; and for selection of operators with suitable qualifications and for their protection against arbitrary dismissal. Originally there were two schools of thought in respect to procedure desirable; one advocating drastic prohibition of all discharge of untreated sewage into waters of Great Lakes; the other, chiefly from considerations of financial feasibility, favoring progressive program imposing no undue strain on financial resources, as likely to attain the desired goal more quickly. An intermediate course seems to be necessary. Effective leadership calls for coöperation, friendly advice to local authorities, and active coördinated program to secure adequate support of public opinion. Local conditions vary and should be studied in formulation of working program, so as to take into account individuality of each locality, with its trade waste and other characteristic problems. Of applicable methods for finishing treatment of sewage, (1) trickling filters are cheapest, generally. But (2) activated sludge process is of unquestioned reliability and suitable for practically all locations. With preliminary sedimentation and gas utilization, its cost as compared with that of trickling filters becomes less unfavorable. It effects bacterial removal of about 90 percent and, correspondingly, a very great reduction in dose of chlorine needed for technical sterilization. For water treatment, mechanical, or rapid sand, filtration, with coagulants, is indicated, supplemented by sterilization. Influence of trade wastes is becoming more serious each year. For many weeks in an ordinary year Lake Michigan water without filtration falls far short of modern requirements. At times when wind storms and other conditions cause rapid fluctuations in quality, the frequent readjust-

ment of chlorine dosage to chlorine requirement of raw water presents great difficulties. Without filtration and chlorine, or other, sterilization, water supplies derived from Lake Michigan cannot be brought up to modern requirements. **Water Supply.** GEORGE H. FENKELL. 33–37. Water supply is now necessary preliminary to building operations of the growing city. High population densities have lived for some time with pure water supply and electricity as the only public services. Necessity of former is no longer debatable. Drinking water should be at all times colorless, or nearly so, free from turbidity and from odor, and of reasonable softness. Near shore waters of Great Lakes generally meet these requirements. It is logical to expect shore cities of Great Lakes to show marked increase in populations within a few years. Increased population and decreased ground water supply may make it necessary for cities as far inland as 100 miles to have recourse to lake water supplies. Near large centers of population natural purification is insufficient to justify use of raw lake water without treatment. If each city and town were to remove its own nuisances and pollution, major portion of present insanitary condition of Lake Michigan would be corrected. In Great Lakes water supplies, following points are important. (1) Location and construction of intake: openings should be of liberal size, deep, and free from perils of navigation and it should be able to withstand storms and ice pressure. (2) Conduit: steel plate construction seems most promising for large sizes, while reinforced concrete is being carefully considered. (3) Screens: preferably elsewhere located than in intake structure. (4) Pumps: present tendency is toward motor- or steam-driven centrifugal pumps: local conditions alter cases. (5) Pumpage rate and storage requirements. Confining treatment merely to chlorination is of nature of a make-shift. Construction costs of filtration works are not excessive; nor is their design any longer experimental. Operation should be under guidance of trained chemist and bacteriologist: this applies even to small plants. **Some Aspects of the Sanitary Problems on the Watershed of Lake Michigan.** GEORGE G. EARL. 39–44. Until recently, diversion canals have successfully carried off most of sewage from densely populated areas, drawn water from deeper levels to lake intakes, and enriched with oxygen the diverted polluted water. This system is no longer adequate to increased population. First problem, therefore, is to purify sewage discharges, whether entering diversion canals, or, indirectly, Lake Michigan itself. This is practicable for dry weather flow; but not for frequent storm flows. Combined diversion and withdrawal of 10,000 second-feet are insufficient to prevent occasional reversals of flow of Chicago River and frequent discharge of Calumet River into lake. This has in turn necessitated objectionable excessive chlorination of drinking water supply, and need is clearly indicated for adequate filtration, metering, and elimination of waste. Area and population of Sanitary District have increased from original 185 square miles and 2.5 millions to 437 square miles and 3.3 millions. Therefore diversion allowance of 10,000 second-feet appears now too small for protection. Comparison is made with New Orleans. Independently of Chicago diversion, lake levels continually fluctuate and must in many seasons reach objectionably low stages. Increasing population will tend to increase storm flows and exceed more and more the diversion capacity, with resulting reversals of flow into

Lake Michigan. Creation and maintenance of clean Lakes-to-Gulf waterway system are urged. **Address of Edward Cochrun, Secretary, Department of Conservation, Michigan.** 45–47. Condition of public waters today is worse than public realizes. In early days pollution was not the menace it gradually became. Now 85 percent of America's public waters are polluted, some grossly, so that fish life has been depleted with resulting recreational and economic loss. Practically, pollution increases in direct proportion to growth of cities and industry. In Michigan, definite plan has been started to clean up streams of state from domestic and industrial wastes. **Sewage Treatment from the Chemical Point of View.** WM. R. COPELAND. 48–50. **Sanitation in Illinois.** ISAAC D. RAWLINGS. 51–59. Author refers to specific instances in Illinois where state sanitary engineering staff gave unheeded warnings of danger attending insanitary conditions. Later events justified these warnings and enabled staff to institute emergency relief measures of nature first recommended. Illinois State Health Department possesses no legal enforcement power, hence functions only in advisory capacity. Brief record is given of sanitation of following Lake Michigan communities and territories, from Illinois-Wisconsin line to Illinois-Indiana line; Winthrop Harbor, Camp Logan, Zion City, Waukegan, North Chicago, Great Lakes U. S. Naval Training Station, Lake Bluff, Lake Forest, Fort Sheridan, Highwood, Highland Park, Glencoe, Winnetka, Kenilworth, Wilmette, Evanston, Chicago, and Calumet City. **Progress Report. Lake Michigan Investigation.** H. R. CROHURST. 60. Investigation of southern end of Lake Michigan State conducted by Chicago Sanitary District and Chicago Board of Health, and State Boards of Health of Indiana and Illinois in coöperation with the U. S. P. H. S. **Importance of Maintaining the Purity of Lake Michigan Waters.** HARRISON P. EDDY. 61–65. It is probable that majority of water supplies derived from the lake should be filtered as well as chlorinated. There will occur, even under most favorable conditions, unavoidable pollution resulting from surface wash, from storm water overflows, from navigation and, somewhat, from recreational use of lake. Consequently, it is the part of wisdom to exclude, as far as practicable, preventable pollution. From aesthetic standpoint alone, lake should be free from visible evidence of sewage pollution, such as floating trash, oily scum, and discoloration. Sewage disposal and water supply problems are affected to large extent by local conditions. At southern end of lake, it seems highly desirable that the various communities outside Sanitary District of Chicago should adopt such policies with respect to discharge and treatment of sewage and wastes as will be in general harmony with policy of the District and will have as common objective maintenance of purity of lake waters. **Sanitary Conditions in Wisconsin.** C. M. BAKER. 66–67. Author states Wisconsin is one of most sanitary states in Union. **The Sewage Treatment Program of the North Shore Sanitary District.** JOHN OLIVER. 67–69. Seven photographs and table included. **Calumet City Sewage Treatment Plans.** GEORGE O. CONSOER. 80. Includes two photographs. **Milwaukee Sewage Disposal Plant.** T. CHALKLEY HATTON. 81–84. **Lake Michigan Sanitation Congress Resolutions (4)** 84–85. **Typhoid Fever and the Water Supply and Sewage Conditions Around the Great Lakes and Lake Michigan in Particular.** LANGDON PEARSE. 86–93. Six tables of typhoid

death rates with explanatory notes and some additional information are given to supplement and bring up to date the compilation entitled, "Typhoid Fever and the Water Supply and Sewage Conditions around the Great Lakes," by LANGDON PEARSE and S. L. TOLMAN, Jour. A. P. H. A. 13: 1, 41, January 1923. **Typhoid Fever in Chicago in 1925.** HERMAN N. BUNDESEN. 94–108. Three charts and 10 tables describe history of typhoid control in Chicago from 1891–1925. It is noted that peaks of typhoid incidence occurred in years 1872 and 1891, with 142 and 173 per 100,000 respectively, and that chlorination of water was started in January 1912.—*R. E. Noble.*

ERRATUM. Volume 24, April, 1932, page 605, line 22. For "400 p.p.m. alkalinity]" read "[200 p.p.m. alkalinity]".